THE FUTURE OF SMART GRID TECHNOLOGY
IN THE U.S. LODGING INDUSTRY:
A DELPHI STUDY

by

Diane M. Vondrasek

A thesis submitted to the Faculty of the University of Delaware
in partial fulfillment of the requirements for the degree of
Master of Science in Hospitality Information Management

Summer 2011

Copyright 2011 Diane M. Vondrasek
All Rights Reserved

THE FUTURE OF SMART GRID TECHNOLOGY

IN THE U.S. LODGING INDUSTRY:

A DELPHI STUDY

by

Diane M. Vondrasek

Approved: ____
Francis A. Kwansa, Ph.D.
Professor in charge of thesis on behalf of the Advisory Committee

Approved: ____
Paul J. Sestak, AIA
Professor in charge of thesis on behalf of the Advisory Committee

Approved: ____
Robert R. Nelson, Ph.D.
Chair of the Department of Hotel, Restaurant and Institutional Management

Approved: ____
Rick L. Andrews, Ph.D.
Interim Dean of the Alfred Lerner College of Business and Economics

Approved: ____
Charles G. Riordan, Ph.D.
Vice Provost for Graduate and Professional Education

ACKNOWLEDGEMENTS

Conducting research is like traveling a challenging road in a foreign land. No matter how well you are equipped to maneuver; there are times when you cannot proceed unguided. I was blessed with the very best of guides, Dr. Francis Kwansa, Dr. Ali Poorani and Professor Paul Sestak.

Dr. Kwansa's gentle, firm and unending support led me as I learned the rules of the research road. I knew I could count on him to extend a hand when I stumbled. His patience with my exuberant ramblings was nothing short of saintly. Guiding me was a big job, and he never failed. I shall be forever grateful.

Dr. Poorani's sincerity, practicality and optimism provided a clear perspective when fog descended on the road. His encouragement and warmth lifted the fog, and illuminated what would have otherwise been murky times.

Professor Sestak's perceptive powers and appreciation of the historic underpinnings of the lodging industry confirmed the value of my academic instincts. His recognition of the value of history, and the significant role it plays in the present, allowed me to consider the history of all matters. Because of Paul, I saw the road with wise eyes.

I would not have finished my thesis, or be writing this acknowledgement, without the intellect, talent, and grace with which Dr. Kwansa, Dr. Poorani, and Professor Sestak guided my research. I have learned more than I believed possible from them, and my life has been enriched by their generous spirits.

I am fortunate to have been associated with a gifted academician who knows that the best way to teach is by example. I learned what "hospitality" really meant from Dr. Robert Nelson as his honesty and compassion consistently defined the term.

I am grateful to Dr. Naveed Baquir for introducing me to, and providing first-rate examples of, the Delphi method; and to Dr. Sri Beldona for teaching me the criticality of the science of service in the hospitality industry with humor and enthusiasm.

The lodging industry is a wonderful place, populated by willing mentors who routinely run marathons all over the world. They anchor us in the finest hospitality traditions, while simultaneously urging us to strive to be the best world citizens we can be. I owe my improved running skills to Hervé Houdré, who gave me firm footing and consistently confirmed that we are truly all connected.

After reading mountains of Delphi Study descriptions, I braced myself for the loss of study experts. However, an incredible group of Olympic-class runners collaborated so beautifully through the study rounds that I often had to pinch myself to make sure I wasn't dreaming. All very busy practitioners, they consistently and graciously delivered such high quality discourse that the Delphi study conclusion was bitter-sweet for me. I sorely missed peering at their insights through the study window but I was excited about describing their collaborative discussion in writing. Their reliable participation and willingness to help a

graduate student explore uncharted territory was a testament to the generosity and forward-looking thinking that permeates the industry. Thank you, one and all.

I owe a great deal to my friends Jamie Frank, Jim Hogan, Teresa Hogan, Edna Johnson, Mimi Kimbrough, Donna Laws, Lisa Marcinkowski, Diane Moss, August Muzzi, Terri Muzzi, Beth Offutt, Janice Penrod, Donna Richards-Bank, Parisa Salkhordeh, Dana Shade, Rick Simmons and Sara Thompson, who shared their considerable knowledge, without hesitation or reserve, and provided a constant source of advice and encouragement. The world has never seen a better cheerleading squad!

I dedicate this thesis to my daughter, Britannia Vondrasek, and my nephew, Adam Ernest, who kept the faith and stood staunchly beside me, as I overcame the hurdles of graduate student life. Their unfaltering confidence in me was the brilliantly shining light I sought at the end of the road. They were, and are, my ultimate inspiration.

TABLE OF CONTENTS

Appendix

LIST OF FIGURES

LIST OF TABLES

LIST OF ABREVIATIONS AND ACRONYMS

AC	Alternating current
ADR	Average daily room rate
AHLA	American Hotel & Lodging Association
BPL	Broadband over powerline
CCHP	Combined cooling, heating and power systems
CPCN	Certificate of Public Convenience and Necessity
CPUC	Colorado Public Utilities Commission
CQ	Cornell Hospitality Quarterly
CR	Corporate Responsibility
CSCTG	Cyber Security Coordination Task Group
DOE	U.S. Department of Energy
DR	Demand Response
DWH	Domestic water heating
EIA	Energy Information Agency, U.S. Department of Energy
EIS	Energy information system
EMS	Energy management system
EPA	U.S. Environmental Protection Agency
EU	European Union
EV	Electric vehicle
FERC	U.S. Federal Energy Regulatory Commission
HVAC	Heating, ventilation and air conditioning
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IPP	Independent power producers
ISO	Independent system operator
MR	Mean Rating
N	Number of Delphi study participants
NDRC	National Development and Reform Commission of China
NEA	National Energy Administration of China
NIST	National Institute of Standards & Technology
P.E.	Professional Engineer
PG&E	Pacific Gas and Electric
PMS	Property management system
REC	Renewable Energy Certificates
RES	Renewable Energy Standards
ROI	Return on Investment
SD	Standard deviation

SERC	State Electricity Regulatory Commission of China
SGC	SmartGridCity
SGCC	The State Grid Corporation of China
SGIP-GSWG	Smart Grid Interoperability Panel-Cyber Security Working Group
SGN	Smart Grid Newsletter
V2G	Vehicle-to-grid

ABSTRACT

The purpose of this research is to discover emerging issues associated with smart grid technology adoption in the U.S. lodging industry through discussion and consensus of industry experts. United States lodging industry experts were asked to identify critical issues relating to smart grid technology adoption in the industry for the planning horizon ending December 30, 2020. A Delphi study was conducted. Through three rounds of a series of questions, industry experts' perceptions of currently adopted and anticipated future smart grid technologies in the U.S. lodging industry were recorded, analyzed and ranked. The study provides a baseline for the U.S. lodging industry that may be used to assess industry progress as smart grid technologies are developed and adopted. The benefits of collaborative academic research that elucidates practical solutions to challenges posed by multi-discipline forces are highlighted in study results. Study conclusions provide direction for those who are making decisions about smart grid technology adoption and for those who are charged with providing exceptional service while achieving energy efficiency.

Keywords: energy management, electric grid, information technology, hotel, lodging, loyalty programs, power generation, renewable energy, smart grid, smart grid technologies

Chapter 1

INTRODUCTION

1.1 Introduction

This research is an exploratory study of the perceptions of U.S. lodging industry experts about the recognition, benefits, challenges and risks of adopted and anticipated future smart grid technologies. The goal of this researcher is to accurately identify and report these perceptions. The study will serve as a baseline for smart grid technology adoption progress in the U.S. lodging industry.

The current electric grid model is tied to the past, so Chapter 1 begins with a historical perspective of the national grid. Descriptions of how the national grid works, and how consumers are charged for electricity from the grid, follow. A comparison is made between the existing grid and the smart grid. Three primary differences - energy flow, data flow, and fuel mix - are identified, examined, and graphically depicted. The smart grid and smart grid technologies are defined. Subsequent sections provide a framework in which the picture of smart grid technology adoption in this research is viewed. The value of collaborative research that advances technology as a solution to industry challenges is discussed and the research questions are presented. Subsequent chapters contain the literature review; study methodology; study results and discussion; and conclusions, including recommendations for future research.

1.2 Historical Perspective of the National Electric Grid

The U.S. electrical system initially consisted of isolated local areas with two electric power components; generation and distribution. The grid was developed to interconnect isolated areas, enabling electric power transmission, and creating a network of formerly isolated areas. Instead of having small islands, or local areas, of generation and distribution, the system was expanded into three components; generation, transmission, and distribution, and it allowed electric power suppliers to take advantage of economies of scale.

Power quality was poor before the transmission component was added, simply because of the nature of supply and demand. For example, if a local power generator could not meet demand, the drag on limited generation capacity resulted in sagging electrical frequencies and voltages. During the early days of the system, most of the power load was for lighting. When demand exceeded supply, the resultant "sags" merely caused lights to dim. From a practical perspective, this was a benign problem, but as electricity started to be used for devices such as motors, radios and other communications devices, power quality became important. It became necessary for electrical voltage and frequency to be maintained at standard levels.

Consistent power quantity, or reliability, followed much the same path as power quality. Before the transmission component was added to the electrical power system with the development of the grid, there was nowhere to get supplemental power when demand exceeded supply. These circumstances resulted in a system that could not reliably furnish electric power. This was especially problematic when there was zero supply, as was the case when local generation facilities went off-line, usually because of equipment failure.

Transmission, the third power component, allowed electricity to be transported, or transmitted, between formerly isolated areas, resulting in improved quality and reliability. Local power generators began to establish transmission interconnections, or grids, by building transmission lines with neighboring power suppliers to improve quality and reliability. Local grids developed into regional grids which, collectively, make up the national grid as we know it today. The national grid, with its interconnecting transmission capabilities, allows customers to receive power from adjacent power producers, resulting in a more reliable system than was formerly available. The simplified diagram of alternating current (AC) electricity distribution from generation stations to consumers (Federal Energy Regulatory Commission, 2006) below shows the three components - generation, transmission and distribution - of the grid.

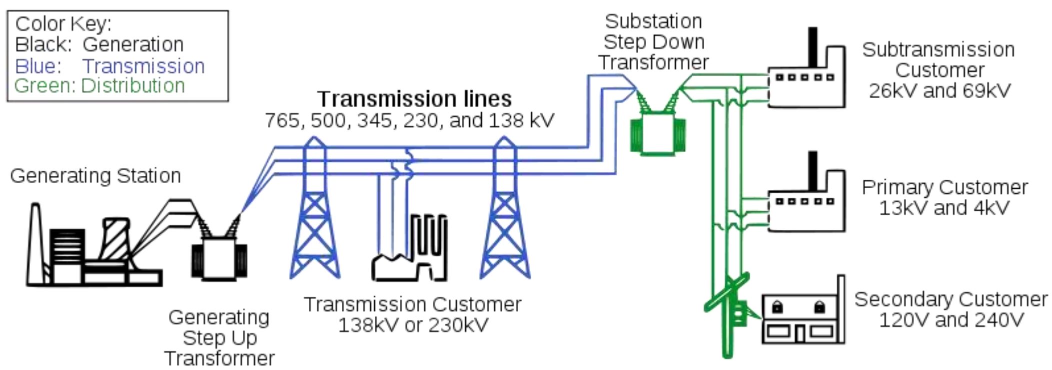


Figure 1: Simplified Diagram of Ac Electricity Distribution from Generation Stations to Consumers

1.3 How the Grid Works

The national grid is the transmission system for the United States. Energy companies obtain power from their own generating facilities and/or they buy it from the grid. Power is purchased off the grid by power distribution companies and large industrial customers. Put simply, power distribution companies sell power to commercial, residential and relatively small industrial customers; and large industrial customers who purchase power directly off the grid use the power they purchase in-house. This is where market forces come into play – energy companies choose a power mix, based on contracted and real-time pricing. Again, supply and demand are at the fore. For example, if the east coast experiences an extreme sustained heat wave at an unpredicted time, the companies that supply power up and down the east coast are forced to scramble to purchase power from the grid, creating a situation in which power prices are driven up because demand heavily exceeds supply. Moreover, if an unplanned outage occurs at a generation station, the company that owns the station adds to the fray by driving demand even further to make up for lost generation capacity, thereby driving the price of power from the grid even higher.

1.4 How Consumers Are Charged for Electricity

In general, energy distribution in the U.S. is the domain of companies with geographic territories. Each company charges customers for the distribution of electrical power into homes and businesses that are located within the company's territory. In the United States, energy providers are generally regulated by state utility commissions. There are exceptions, and there is a trend toward deregulation, but state utility commissions still regulate generation, transmission and distribution, or any combination thereof, depending on the state. Consumer usage information is manually or remotely read from meters, usually monthly, in kilowatt hours (kWh). Consumer charges are calculated by multiplying rates ($/kWh) by usage (kWh). It is important to note that this is a simplified explanation of a complex rate system that is "tiered" depending on season, usage volume, and consumer type (residential, commercial, industrial).

1.5 The Existing Grid and the Smart Grid – A Comparison

There are three primary differences in the function of the existing electrical grid and the smart grid. They are:

1. Energy Flow
2. Data Flow
3. Fuel Mix

1.5.1 Energy Flow

Figure 2 illustrates existing grid energy flow. Energy flows *in one direction*, from generating facilities, through the grid transmission lines and, ultimately, to consumers via distribution lines.

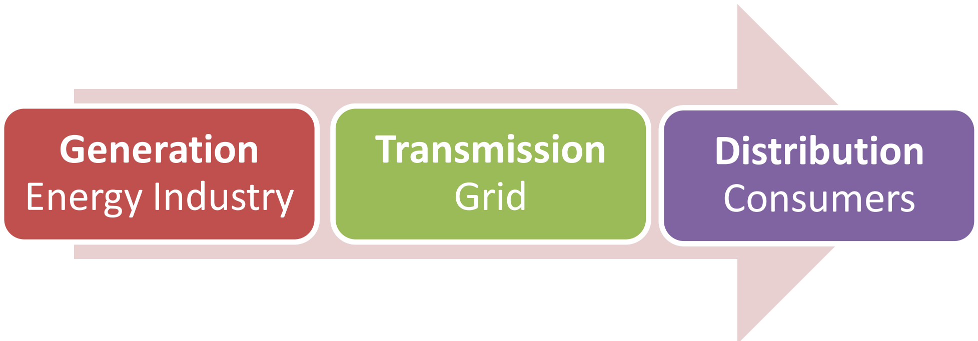


Figure 2: Existing Grid Energy Flow

Figure 3 illustrates smart grid energy flow. Smart grid technologies allow energy to flow *in a loop* in which energy may be *exchanged* between stakeholders. Consumers have the ability to join energy providers in an enhanced role as energy consumer/generators.

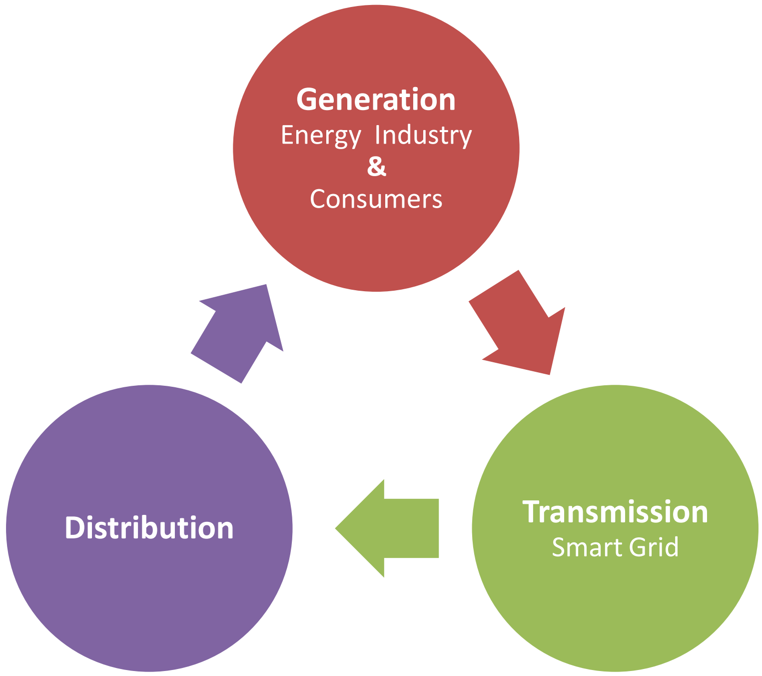


Figure 3: Smart Grid Energy Flow

1.5.2 Data Flow

Figure 4 illustrates existing grid data flow. Data flows *in one direction* from the consumer to the provider, with no actionable real-time feedback. Aggregate usage is manually or remotely read from consumer meters by energy providers, and consumers receive an after-the-fact billing invoice. Consumers participate *passively* in current data flow because they do not have the ability to identify specific energy usage patterns in real-time.

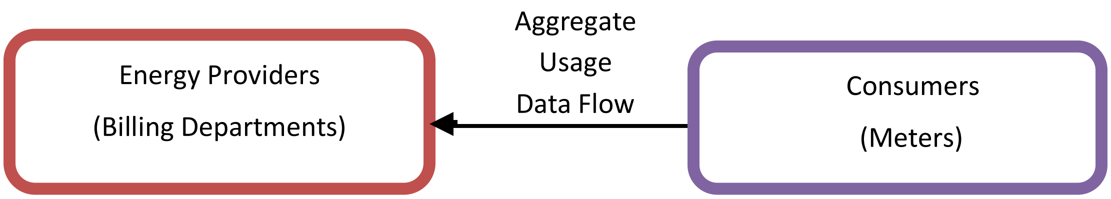


Figure 4: Existing Grid Data Flow

Figure 5 illustrates smart grid data flow. Data resides in a "cloud" in real-time, *moves in multiple directions*, and is accessible by consumers as well as energy companies as actionable information. Measurements taken using smart grid communications technologies are precisely time-synchronized, taken many times per second and displayed digitally, thereby facilitating consumer action by allowing consumers to *actively* respond by adjusting consumption. Smart grid technologies automatically read meters, record power consumption habits and support remote control. Consumers are provided with options to choose low-cost electricity, level electricity consumption amounts between peak and low hours, and reserve electricity for emergency use. Real-time power costs, energy consumption habits, and energy use suggestions are all accessible through smart grid technologies.

The consumer role is expanded, with consumers having the potential to become consumer/generators. Smart grid technologies facilitate grid-connected intermittent generation from sources such as wind, solar, and vehicle to grid (V2G) vehicles, by using these sources during peak usage times and replenishing it during off peak times. Residential, commercial and industrial consumers alike have access to their carbon emission amounts and suggestions for reductions. Smart grid technologies have the capacity to provide usage transparency wherein real-time usage data is available to consumers, consumer/generators, energy providers, and third party recipients.

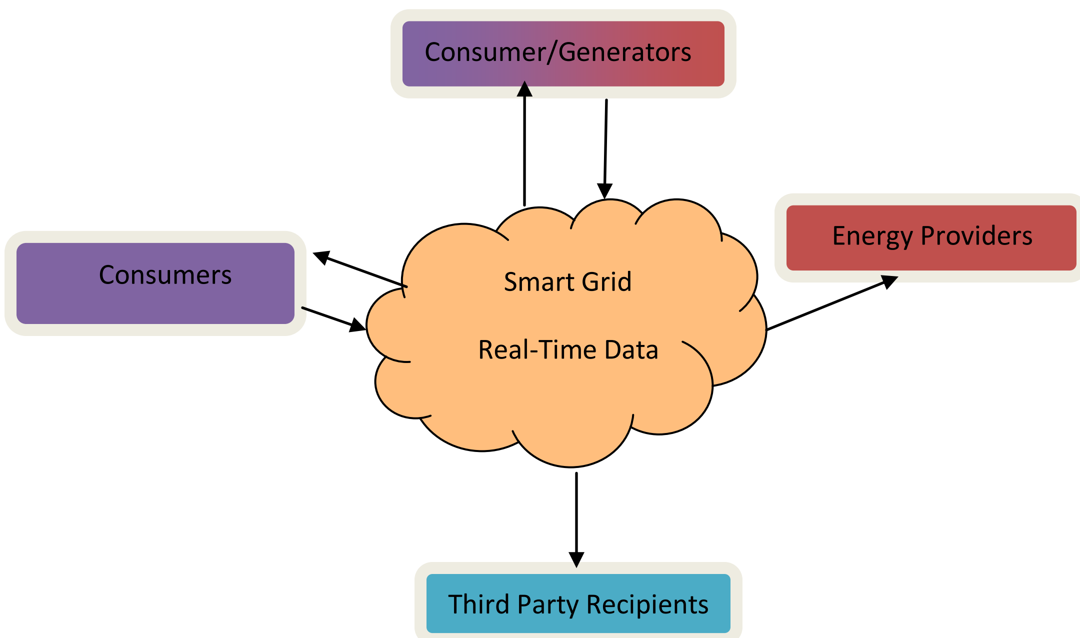


Figure 5: Smart Grid Data Flow

1.5.3 Fuel Mix

Figure 6 illustrates the 2009 U.S. fuel mix (U.S. Energy Information Administration, 2011). Energy companies and large independent generators supply power to the grid. Fuel sources remain predominantly controlled by large utility companies. Primary sources - coal, natural gas and nuclear - are nonrenewable fuels.

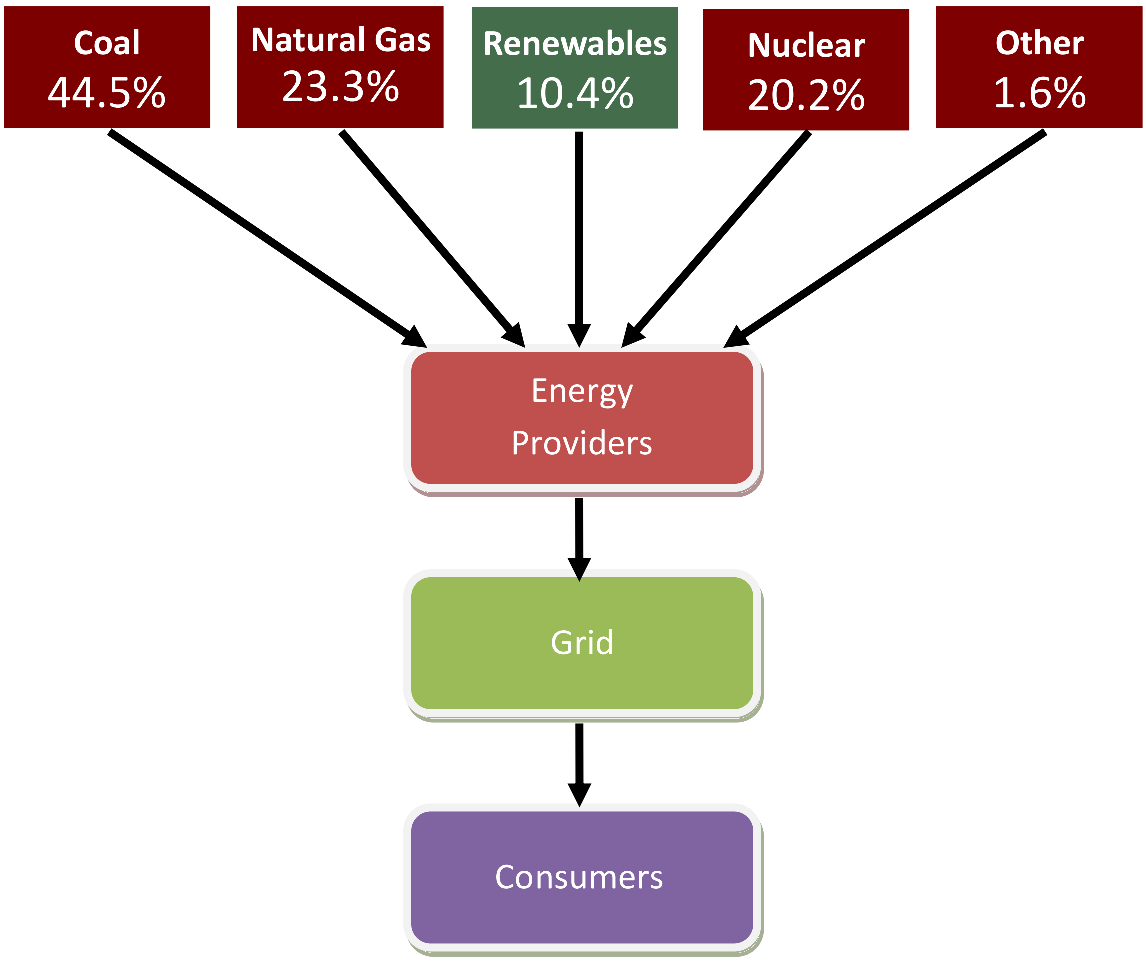


Figure 6: 2009 U.S. Grid Fuel Mix

Figure 7 illustrates potential smart grid fuel mix. Smart grid technologies facilitate the use of intermittent renewable fuel sources such as wind, solar, and hydroelectric. Smart grid technologies allow all forms of fuels, renewable and non-renewable, to have equal access, as capacity permits, to the smart grid. The installation of a smart device, a net meter, allows independent generation sources to be connected to the grid, resulting in reduced dependence on external sources. Consequently, power producers of all sizes, including commercial consumers, have the opportunity to produce electricity with various sources and methods of their choice. Smart grid technologies facilitate *exchanging and selling* self-generated power to the smart grid by automatically balancing the electrical power load on the grid.

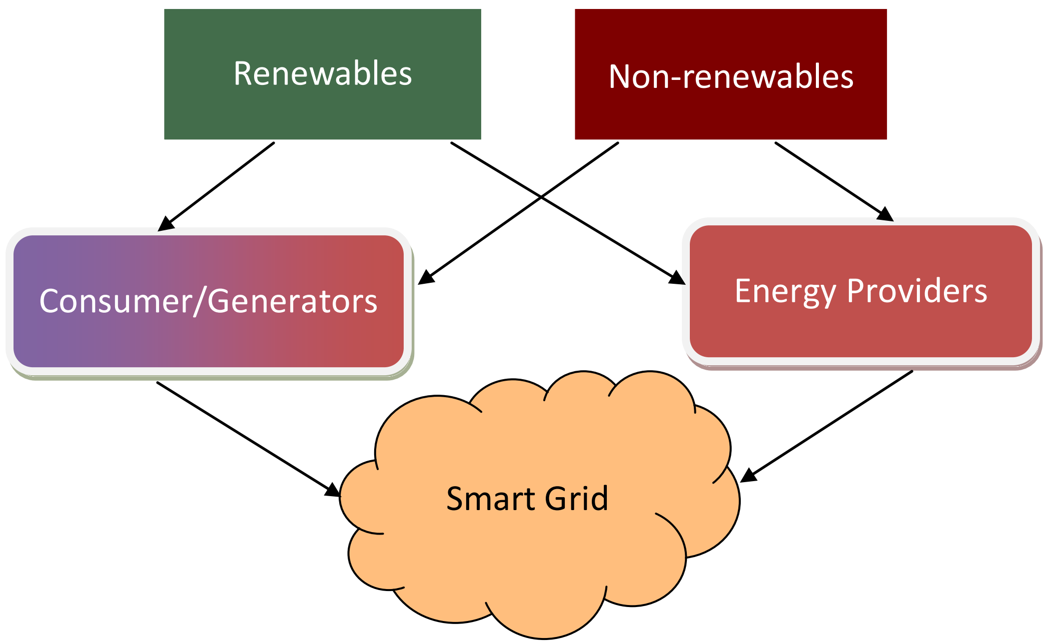


Figure 7: Potential Smart Grid Fuel Mix

1.6 Smart Grid and Smart Grid Technology Defined

The U.S. Department of Energy (2008) describes the transformation of the grid into the smart grid as

> . . . a transformation from a centralized, producer-controlled network to one that is less centralized and more consumer-interactive. A smarter grid

> makes this transformation possible by bringing the philosophies, concepts and technologies that enabled the internet to the utility and the electric grid. More importantly, it enables the industry's best ideas for grid modernization to achieve their full potential. . . . many of these ideas are already in operation. Yet it is only when they are empowered by means of the two-way digital communication and plug-and-play capabilities that exemplify a smarter grid that genuine breakthroughs begin to multiply. Adoption of the Smart Grid will enhance every facet of the electric delivery system, including generation, transmission, distribution and consumption.
>
> The Smart Grid Newsletter (SGN) is the insider's guide to this rapidly growing market. Sponsored by the Department of Energy, the GridWise Alliance, Pacific Northwest National Laboratory and other Smart Grid leaders, SGN serves the business, financial, utility, and entrepreneurial communities. It is also widely read by researchers, policymakers, government agencies, economic development groups, and others who have a stake in the progress of the electric system (Power Partners, 2009).

SGN defines the smart grid as "The application of digital technology to the electric power infrastructure" (Smart Grid News, 2010). The 'digital technology' in the SGN definition is smart grid technology. Various forms of smart grid technology, used by industrial, commercial, and residential consumers enable the smart grid. Smart grid technologies facilitate renewable resource generation integration, advanced energy storage options, electric vehicles (EVs) and V2G support, energy information systems (EISs), energy management systems (EMSs), property management systems, demand response (DR) systems, load balancing systems and a myriad of other 'smart' energy management tools.

1.7 Energy Issues in the U.S.

The reliability of the US electrical grid is declining. “There have been five massive blackouts over the past 40 years, three of which have occurred in the past nine years.” “This issue of blackouts has far broader implications than simply waiting for the lights to come on.” “41% more outages affected 50,000 or more consumers in the second half of the 1990s than in the first half of the decade. The “average” outage affected 15 percent more consumers from 1996 to 2000 than from 1991 to 1995 (409,854 versus 355,204)” (U.S. Department of Energy, 2008).

> Even as demand has skyrocketed, there has been chronic underinvestment in getting energy where it needs to go through transmission and distribution, further limiting grid efficiency and reliability. While hundreds of thousands of high-voltage transmission lines course throughout the United States, only 668 additional miles of interstate transmission have been built since 2000. As a result, system constraints worsen at a time when outages and power quality issues are estimated to cost American business more than $100 billion on average each year. In short, the grid is struggling to keep up (U.S. Department of Energy, 2009).

The average cost of electricity in the U.S. increased 2.5% from 2008 to 2009, 0.4% from 2009 to 2010, and is projected to increase 1.4% from 2010 to 2011 (U.S. Energy Information Administration, 2011). The bulk of U.S. electricity is produced with nonrenewable fuels that are increasing in cost at greater rates than recent electricity rates. In the U.S., these rates have been controlled by regulatory action, but this is a strategy that cannot continue. It is a simple case of supply and demand. As the demand for fuels outpaces supply, costs will escalate. Electricity prices are forecast to increase 50% over the next seven years (U.S. Department of Energy, 2009). U.S. industries are particularly vulnerable because consumption is supplemented largely by fuels from foreign countries. As long as U.S. industries rely on foreign sources to fuel electricity supply, this will place them at a disadvantage in an increasingly competitive global marketplace. Eventually, all consumers, commercial consumers included, will pay the full price for the fuels used to generate electricity.

1.8 Legislative Trends

At the state level, thirty states plus the District of Columbia have Renewable Energy Standards (RES) in place. RES place an obligation to generate a specified percentage of electricity from renewable energy technologies and they apply, in varying degrees, to electric utilities depending on size and type. By requiring electric utilities to increase renewable fuel generation capacity, dependence on fossil fuels is reduced. RES goals are mandatory in all but one of the thirty states (Vermont is the exception with a voluntary goal) and other states set interim yearly goals. Federal legislation is being worked on in the U.S. Senate but, regardless of where the legislation lies, RES is here to stay. An economic incentive, a carbon tax, is also under consideration. If enacted, taxes will be levied on energy producers using carbon producing fuels in the production of electricity. Should a carbon tax become a reality, electric power generation fed by renewable sources will become more economically viable and smart grid technologies ever more valuable.

A mechanism for trading renewable energy generation, Renewable Energy Certificates (RECs) has been developed. RECs make the advantages of renewable fuel generation available in areas where renewable generation is impossible or unavailable, such as in dense urban areas where the installation of renewable fuel sources such as wind, hydro, and solar technologies are not feasible because of space limitations.

> Both individual and organizational buyers have several green power product options available. These include buying renewable energy certificates RECs by themselves, buying RECs along with physical electricity from their utility service provider, or developing onsite renewable projects that produce both electricity and RECs together. RECs in particular have become an important choice for buyers of green power nationwide and serve as the 'currency' for renewable energy markets (U.S. Environmental Protection Agency [EPA] 2008).

While the EPA statement focuses on RECs providing green power options, RECs also have the important benefits of potential financial savings and they may be used to satisfy mandatory renewable fuel generation targets.

1.9 A Technological Solution

Current U.S. federal administration members clearly believe in the power of technology to solve the nation's electricity shortfalls. Billions of dollars of economic incentives, in the form of cash, loans, and tax credits, have been made available to spur smart grid technology innovation. Stimulus awards have been accepted by businesses, small and large, with the capabilities to innovate smart grid technologies. The Smart Grid Technologies market in the U.S. is currently estimated to be more than $6 billion, and is forecasted to grow at a compound annual growth rate of almost 21%, with a projected total of $17 billion by 2014 (SBI Energy, 2009). The implications and benefits of smart grid technology adoption are not lost on the nation's financial markets.

Technology acting as a catalyst for innovative solutions for scarce non-tangible goods, like electricity and bandwidth, is not a new concept. "Bandwidth trading is defined as the exchange of rights to move data across telecommunications lines at a future date" (New Paradigm Resources Group, 2001). In practical terms, bandwidth trading is a process where bandwidth is sold by users with too much capacity to those with insufficient capacity. In May, 1999, before becoming America's biggest corporate failure, Enron created one of the world's largest companies, including an online bandwidth trading business. The major broadband suppliers (cable companies) were hostile to bandwidth exchanges for a number of reasons. First, Enron's successful bandwidth exchange markets would have diluted cable company market share. Second, successful bandwidth exchanges would have rendered international carriers product differentiation marketing efforts ineffective and unprofitable. Providers subsequently built bandwidth infrastructure, laying thousands of miles of fiber optic cable, capable of efficiently moving digital data that resulted in bandwidth supply that exceeded demand. Bandwidth was no longer scarce. Consequently, the business model changed; media was decoupled from bandwidth. Bandwidth providers now charge for content, not the telecommunications lines that media content moves through, and the cost to consumers has decreased significantly.

Like media and bandwidth decoupling, electric distribution was decoupled from transmission, but there is a critical difference between bandwidth and transmission that will preclude a similar outcome. Communications companies were able to orchestrate a massive infrastructure build-out that resulted in supply exceeding demand that continues to this day, but energy suppliers are not in a position to build enough generation capacity to exceed, or even meet, increasing demand. Most importantly, the fiber optic cable that serves as the medium to transport digital data in the bandwidth world was paid for by investment in the dot.com bubble. Despite the appearance of expensive smart grid technology development, implementation and development will be significantly more cost effective than the build-out of electric generation capacity for which there is no financial investment bubble to tap. Electricity trading has been a routine practice between utilities for decades, but electric power regulators are charged with striking a balance between independent power generators of all sizes and large electric utility companies. Smart grid technologies will enable commercial, industrial and residential consumers to participate in trading, as illustrated in Figure 3.

From a practical business perspective, major electricity suppliers, as well as complementary equipment and software manufacturers, have signed on to the smart grid concept, unlike the communications companies who refused to participate in bandwidth exchanges. Many smart grid technology players have taken advantage of stimulus funds, tax credits and other incentives. Some have already installed smart grid technologies in the forms of smart meters, load balancing software, and demand response applications. Federally funded smart grid pilot projects, funded by the American Recovery and Reinvestment Act, abound. Consequently, the viability and integrity of the smart grid energy exchange system is guaranteed.

1.10 Security and Privacy Challenges

All new innovations come with challenges, and smart grid technologies are no exception. Security and privacy are two of the major challenges of smart grid technology adoption.

The primary cyber security risk for smart grid data is posed by data existing on, and moving in and out of, a “cloud”, as illustrated in Figure 5. The “cloud” is a central concept in information system virtualization. As formerly isolated systems are interfaced with smart grid information communication systems, there is much to be considered.

From a national security perspective, the surest way to bring a country to its knees is to compromise its electrical supply. For this reason, U.S. federal and state governments have provided billions of dollars of stimulus funds for the development of smart grid technologies and for ensuring the security of smart grid systems. However, stimulus funds for the development of smart grid technologies were awarded before security standards were in place. Consequently, some information systems being marketed for use in smart grid applications, particularly packaged systems, may not be designed with smart grid technology implications in mind. The distinction between physical security and cyber security may not have been recognized during the design process, potentially resulting in systems that are woefully inadequate to assure that smart grid data is not vulnerable to cyber-attack. There is also potential liability in existing systems being "patched" in an effort to keep up with smart grid technologies, without complete knowledge of smart grid technology data implications, a situation that is difficult to remedy because development of smart grid technologies is proceeding at a blindingly fast pace.

In the U.S., the Commerce Department's National Institute of Standards and Technology (NIST) is responsible for formulating cyber security standards for the smart grid. The first draft document was published in September, 2009. The current document, NIST 7628, "Guidelines for Smart Grid Cyber Security," was issued in September, 2010. NIST IR 7628 provides the technical background that can inform organizations in their risk management efforts to implement smart grid technologies securely.

As we move from a data storage model to a model that includes data collection, transport, and analysis, the potential for cyber attack increases exponentially. In all industries, information systems are being virtualized to cut costs on hardware and software design and maintenance, but this is a case - to coin an old phrase – where an ounce of prevention is most certainly worth a pound of cure. System virtualization opens up a plethora of cyber security risks. Moreover, as smart grid data becomes more mobile through smart grid technologies, that is, the more the data moves in and out of a cloud, in and out of consumer entities via smart meters, in and out of electric provider entities, in and out of lodging energy management information systems, the potential for cyber breaches will increase dramatically simply because of proliferation of data movement. Couple this movement with the vulnerability inherent in the expected massive data volume serge (commonly referred to as "the tsunami" in smart grid information systems circles) accompanying smart grid technology implementation, and the potential liability inherent in handling smart grid data is staggeringly apparent.

From a privacy perspective, there is increasing evidence that consumers, and the regulatory entities that protect them, will refuse to participate in the smart grid boon if data privacy is not guaranteed. "Data privacy goes beyond the traditional IT security and touches on issues such as corporate culture, data collection policies, and data quality initiatives. Organizations that ignore these additional dimensions increase their risk of having data breaches resulting in financial penalties and lost consumer trust" (Albornoz Mulligan, 2008). The current plan for the smart grid is a centralized data system. The more centralized the system is, the harder it will be to secure, and the more vulnerable it will be to threats. Opposition to centralized smart grid implementation is being voiced by a rising wave of smart grid technology proponents who support widespread adoption of local, or decentralized, micro grids, but the tide has not yet turned.

Many questions remain, but it is clear that the digital constitution of the smart grid, whether governmental policy falls on the side of centralization or decentralization, will enable, rather than deter, potential threats. The demand for those with the skills to ensure security and privacy of data collected by smart grid technologies will intensify as the issue of risk management comes to the fore.

1.11 Lodging Industry Implications

"The U.S. lodging industry is a commercial service industry. Total U.S. electricity demand is projected to increase by 30 percent from 2008 to 2035, with the largest percentage increase in the commercial sector (42 percent), with the service industries continuing to lead the growth" (U.S. Energy Information Administration, 2010).

> On August 14, 2003, the largest power failure in North American history left some 50 million electricity customers across the northeastern United States and southern Canada without power for as long as two days. The blackout occurred at approximately 4:10 p.m.
>
> By 9:30 p.m., the New York Marriott Marquis Hotel in Times Square resembled a refugee camp. The hotel was evacuated earlier after its backup generator failed. More than a thousand people clustered outside the entrance, some of them dozing, in an area illuminated only by the headlights of two hotel vehicles.
>
> Hotel employees passed out pillows, cups of water, fruit and stools. Tail-gate parties started spontaneously on the curb. There were six-packs of beer and bottles of water, sandwiches and pizzas, coolers of drinks floating in tepid water.
>
> Monica and John Noonen of Orange County, Calif., visiting New York City with their two daughters, ages 14 and 8, said they were used to blackouts because they live in California. "But at least in California, they tell you when the blackouts are going to happen," Mrs. Noonen said. (Scott, 2003)

Kwortnik (2005) examined the blackout of 2003. "The lodging industry has faced considerable recent adversity due to human and natural forces that have disrupted vital inputs to the service-delivery system, notably, electric power" (Kwortnik, 2005). The blackout took many hoteliers by surprise. "Hotel managers found themselves scrambling to serve guests overnight in darkened hotels, many of which did not have running water, let alone expected amenities." "Guests were surprised that hotels often did not have backup power to maintain critical systems after emergency power failed" (Kwortnik, 2005). A general manager of an unidentified hotel who responded to the study stated: "I found it interesting that many local people looked at this hotel as an oasis. Some people honestly did not understand why we had no power. Some came in asking what they should do" (Kwortnik, 2005).

> Despite a better understanding of the causes of the blackout of '03 and improvements in coordination across the power transmission system, energy researchers and industry leaders have concluded that the power grid remains vulnerable and that reliability is not certain, yet, on average, [hotel] managers believe that there is just less than an even chance of another blackout-type event in the near future. When asked whether they agreed with the statement, 'We were prepared to deal with service demands during the blackout' only 20 percent of managers agreed that their hotels were prepared" (Kwortnik, 2005).

The evidence was disturbing - hotel managers were acutely aware that their hotels were not prepared for blackouts, but they were relatively ignorant of the high probability of the plight they faced as grid reliability declined. "Although some viewed the blackout as an isolated event, the frequency of power loss due to other forces suggests that lodging managers should reconsider their risk perceptions and ability to tolerate sudden and sometimes extended losses of inputs such as electrical power that are critical to the hotel operation." (Kwortnik, 2005) Kwortnik's findings and the events chronicled here highlight the issues of primary and back-up power system importance in hotels, how best to provide power during inevitable grid power losses, and how smart technologies may be leveraged to secure these systems.

As part of a study in the larger context of environmental management, Scanlon (2007) studied five U.S. hotel properties in Arizona, Hawaii, New York City, Northwest Maine, and San Francisco with data drawn from the year 2000. She concluded, "the use of a corporate benchmark for individual properties to measure current utility consumption performance and to establish future performance objectives is not an effective format" (Scanlon, 2007). The smart grid is all about data in digital form, provided and manipulated by smart grid technologies. It is a world where information systems rule, and all manner of energy usage is knowable and trackable. As smart grid technologies are adopted, the format Scanlon referred to will become a dinosaur because smart grid technologies will allow energy use to be tracked in real-time, right down to the level of each energy-consuming device or appliance, in any definable space. For example, it will be possible to know how much energy is used by a single refrigerator during the time a guest is occupying a room. Hence, the total cost of all manner of consumption in a definable space for identifiable guests will be at the industry's disposal.

Florian v. Wangenheim, Ph.D., Professor of Service and Technology Marketing, Technische Universität München, Germany, in a quotation from Ostrom *et al*., explained:

> The fact that objects can send and store data enables companies to reconfigure, update, and upgrade objects. By analyzing objects' stored data, companies can better understand when, how, and for what purpose customers are using their products. Object connectivity enables manufacturers to be transformed into service and solution providers. There are some challenging elements in this transformation: understanding customers' adoption and usage behavior for new services that are emerging from this connectivity (in particular, remote and smart services), understanding how usage data are predictive of future customer needs and behavior, realizing how such data can play a role in innovation and customer relationship management, and understanding how firms can use those services to transform themselves into service and solution providers that leverage appropriate business models.

The ability to target market guests based on levels of energy usage will become a reality through data collected by 'smart' energy management information systems because energy costs associated with guest occupancy will clearly relate to their profitability. Energy is the second highest cost of running hotels, and as energy prices escalate, this information, combined with guest information contained in legacy information systems, will be valuable and marketable, much like credit score information is today. The digital characteristics of smart grid technologies will enable the formation of energy scores through customer analytics just as technologies that enabled the internet produced the capability to calculate credit scores.

Energy consumption may also be used in the evaluation of lodging real estate portfolio values as data, obtainable through smart grid technologies, is factored into energy scores. For example, a property in Boulder, Colorado, or Austin, Texas, may have a higher energy score than a property in Provo, Utah, or Lubbock, Texas because of the social energy context of these cities; or two similar properties in the same city may be defined by the prevalence, or absence of, environmentally friendly guest energy usage habits, depending on property appeal to various population segments. Independent power generation, and alternate strategies such as RECs, may be reflected in the scores. This idea may sound futuristic to some, but the technology that can make it a reality is on the industry's doorstep.

Loyalty programs have long been a staple strategy of the lodging industry. Lodging companies have historically based rewards on consumption, rewarding guests who buy, and use, more of everything. A benefit of smart grid technology implementation is that it will enable hotel companies to track guest repetitious energy consumption. For example, hotel PMSs enabled with smart grid technologies will have the capability to monitor and track habitual patterns of climate control, lighting, water usage, cleaning and laundry energy requirements, providing much needed, and previously unavailable, guest energy consumption predictability. Customer analytics obtained from smart grid technologies coupled with loyalty program intelligence will be a valuable tool for making marketing decisions. Given the capacity to determine these costs for identifiable guests, it will be prudent to include them in loyalty program profiles, thereby providing an enhanced picture of guest tangible value.

From a marketing perspective, the implications of smart grid technologies are pervasive. There will be many challenging and interesting questions. For example, are vehicle charging station installations to attract customers with EVs prudent? Assuming the cost of the electricity to charge electric cars is incurred by the hotel property, who then, becomes the target of our marketing efforts - the EV owner or the fossil-fueled car owner? Consider V2G vehicles. V2G technology enables power to be returned to the grid from the vehicle, and many other developing technologies will reduce guest net energy consumption. "In October, 2009, Samsung Electronics Co. and LG Electronics Co. separately started selling solar-powered phones, a big step in a budding trend of cell phone makers seeking to tap growing consumer interest in eco-friendly products" (Woo, 2009). Solar cell phone technology will reduce reliance on the grid and it signifies a relevant trend – a shift to renewable power sources that will reduce guest energy use, thereby making guests who own the phones and other self-powering devices more attractive to a hotel from an electricity consumption perspective.

Mark W. Vigoroso, Director, Strategic Market Development, nPhase, a Verizon Wireless and Qualcomm Joint Venture, in a quotation from Ostrom *et al.*, (2010) stated, "Zero-latency alignment between supply and demand of everything from electricity to car parts will enable new service offerings and profit optimization strategies." Smart grid technologies have the potential to change the lodging industry's perception of tangible guest value by enabling hoteliers to accurately assess energy usage for identifiable guests in definable spaces. For the time being, only aggregate data is available to monitor guest energy consumption. There is no real-time measure, but smart grid technologies, such as IP addressable appliances, are being developed that will allow the industry to accurately track guest energy usage in real time. Having a more accurate guest picture that includes energy consumption costs will enhance hoteliers' ability to manage and control associated costs, thereby improving net operating profit. As energy costs rise, the perception of guest profitability may increasingly focus on the concept of using less, rather than more.

Current smart grid standards state that data obtained from consumers in their residences is owned by consumers. Therefore, it is protected from third party use, but does data collected from consumers who temporarily "reside" in lodging properties require the same protection? In the European Union (EU), consumers must expressly opt-in before their data can be used for business intelligence purposes. This ensures that they make a conscious decision about data tracking. The United States has followed an opt-out model, wherein consumer data may be used unless consumers make a conscious decision to deny data use, but there is movement toward the EU model. If the EU model is ultimately adopted, express permission from the hotel guest to collect energy usage data will be required, perhaps at the property level.

The lodging industry is faced with a complex quandary. How may smart grid data be used to obtain strategic advantage, and how will the industry ensure data security and privacy? What security and privacy standards will the industry be required to comply with? Will peripheral standards, such as the Institute of Electrical and Electronics Engineers (IEEE) standards that currently govern payment card industry data, be applied to smart grid data? From a practical perspective, will data obtained from smart grid technologies be useful combined with legacy systems, such as loyalty program systems? Will lodging properties and companies be required to obtain guest permission to collect and mine energy consumption data? More importantly, will guests be willing to have their energy usage monitored? Will usage monitoring be seen as a positive move toward a sustainable future or will it be seen as a personal intrusion?

The answers to these questions are not within the scope of this research, but one thing is certain - lodging information systems used to collect and transport energy usage data will be required to be secure in accordance with a sea of governing standards. On November 3, 2010, the working group associated with NIST 7628, Smart Grid Interoperability Panel-Cyber Security Working Group (SGIP-CSWG), formerly the Cyber Security Coordination Task Group (CSCTG), had 484 members. The lodging industry was not represented on the SGIP-CSWG member list. A proactive approach must be adopted before the tsunami is upon the industry. No matter who is ultimately awarded ownership of the data, every single entity it passes through, including the lodging property that a guest "resides" in, will be responsible for ensuring smart grid data security and privacy.

“In the United States alone, hotels represent more than 5 billion square feet of space, nearly 5 million guest rooms, and close to $4 billion in annual energy use” (United States Green Building Council, 2010)

> On average, America’s 47,000 hotels spend $2,196 per available room each year on energy. This represents about 6 percent of all operating costs. Through a strategic approach to energy efficiency, a 10 percent reduction in energy consumption would have the same financial effect as increasing the average daily room rate (ADR) by $0.62 in limited-service hotels and by $1.35 in full-service hotels (United States Environmental Protection Agency National Service Center for Environmental Publications, 2010).

“Utility expenditures represent the fastest-growing operating cost for hoteliers (increasing by an average of 12 percent per year from 2004 to 2006).” (Energy Star, US Environmental Protection Agency, US Department of Energy, 2007). The operating expenditures described by Energy Star are the largest of controllable costs. There is significant opportunity for energy use reduction, cost savings, and the mitigation of greenhouse gas emissions through cost-effective energy efficiency opportunities. Smart grid technologies have the potential to facilitate managing energy costs in ways that have previously been beyond company control.

In a report published in July, 2008, designed to help gas and electric utilities, utility regulators, and energy users, identify and act on cost-effective opportunities for expanding energy efficiency resources in five commercial sectors - hospitality, retail, commercial real estate, grocery, and municipal - the U.S. Environmental Protection Agency (EPA) cited the lack of comprehensive measurement tools available to the hospitality sector as a primary barrier to energy efficiency.

> The lack of readily available, consistent utility data hinders benchmarking and other energy management efforts. Sector Collaborative participants pinpointed utility data availability and consistency as a major determinant of energy efficiency program success. They recognize the value of continuously benchmarking and tracking their buildings' energy performance improvements. To achieve this, they need access to utility data on a timely, ongoing, and consistent basis, in a standardized electronic format. This issue is especially important for utility customers with properties spread across a variety of utility territories, as well as for customers with multiple properties in a single service territory. (United States Environmental Protection Agency, 2008)

Smart grid technologies that provide the availability and consistency needed for energy management success highlighted in the EPA report have been developed since the report was issued, and many more are in the pipeline.

The financial pain felt by residential customers as energy prices rise will be magnified for U.S. hoteliers. The industry is poised to suffer greater than other industries because of the inability to manage guest energy usage. Of all the commercial sectors identified in the EPA report - hospitality, retail, commercial real estate, grocery, and municipal - the hospitality industry has the least control over energy consumption because the industry relies on guests who, with rare exception, have no vested interest in responsible energy usage while they occupy industry properties. No other industry has less control over occupant thermostat settings or water heating, the two most significant building energy costs. Even hospitals, which house "guests" in rooms, have the ability to control these costs.

1.12 Technology and Academic Research

Ostrom *et al*. (2010), in *Moving Forward and Making a Difference: Research Priorities for the Science of Service,* recognized the importance of academic research that looks beyond researchers' disciplines

> for collaborators who may help frame and investigate service issues in unique ways. Leveraging Technology to Advance Service is an established research area but is in need of significant and novel contributions well into the future. For example, building new business models through smart services, cloud computing and other technologies holds great promise for advances in research (Ostrom *et al*., 2010).

It was with Ostrom's wisdom and the promise of smart grid technology adoption that I embraced this research.

Smart grid technologies can provide leverage to advance service, a concept at the very core of the lodging industry. Answers to the questions of this research provide the foundation for building promising new business models that will allow the industry to advance in this era of impending energy shortages and escalating energy prices. The following questions were the bases for the balance of this research.

Question 1. What smart grid technologies are industry experts aware of that may apply to the lodging industry?

Question 2. How did the identified smart grid technologies come to the attention of lodging industry experts?

Question 3. What smart grid technologies have been adopted in the lodging industry?

Question 4. What are the perceived tangible benefits of adopted smart grid technologies in the lodging industry?

Question 5. What are the perceived intangible benefits of adopted smart grid technologies in the lodging industry?

Question 6. Which adopted smart grid technologies have the greatest benefits in the lodging industry?

Question 7. Which adopted smart grid technologies have negative impacts on the lodging industry?

Question 8. What are the perceived challenges of adopted smart grid technologies in the lodging industry?

Question 9. What are the perceived risks of adopted smart grid technologies in the lodging industry?

Question 10. What are the perceived tangible benefits of future smart grid technologies in the lodging industry?

Question 11. What are the perceived intangible benefits of future smart grid technologies in the lodging industry?

Question 12. Which future smart grid technologies do industry experts anticipate may have the greatest benefits?

Question 13. Which future smart grid technologies do industry experts anticipate may have negative impacts on the lodging industry?

Question 14. What perceived challenges of, or barriers to, do industry experts associate with future smart grid technology adoption?

Question 15. What perceived risks do industry experts associate with future smart grid technology adoption?

Question 16. Which smart grid technologies do industry experts anticipate will be adopted by the end of year 2015?

Question 17. Which smart grid technologies do industry experts anticipate will be adopted by the end of year 2020?

Chapter 2

LITERATURE REVIEW

2.1 Literature Review Scope

An initial literature review was conducted using Boolean searches of five journals, Cornell Hospitality Quarterly (CQ); the International Journal of Contemporary Hospitality Management; the International Journal of Hospitality Management; the Journal of Hospitality & Tourism Research; and the Journal of Travel Research. All searches were performed for the period of January 1, 2005 through September 14, 2010. The search yielded thirteen articles; two articles from CQ, six articles from the International Journal of Contemporary Hospitality Management, four articles from the International Journal of Hospitality Management, one article from the Journal of Hospitality & Tourism Research, and none from the Journal of Travel Research. Seven of the thirteen articles were related specifically to hotel energy management issues. The studies from these seven articles were conducted in Ghana, Greece, Hong Kong, Poland, Sweden, and Turkey.

The geographic scope of this research is confined to the U.S. However, the energy management related literature in the context of this research was overwhelmingly focused outside of the U.S. In order to identify literature about the domestic lodging industry, the literature review was expanded. In addition to the seven articles identified in the initial search, two articles with specific research information about energy consumption in the lodging industry were found in one other lodging industry journal, Tourism Management, but again, the studies were not conducted in the United States. They were conducted in Hong Kong and Turkey.

The literature review was expanded again to include non-hospitality journals. Articles were found in *Applied Energy*, *Applied Thermal Engineering*, *Building and Environment*, *Energy*, *Energy and Buildings*, *Energy Conversion and Management*, *Energy for Sustainable Development*, *Energy Policy*, *Facilities*, *International Journal of Thermal Sciences*, *Renewable and Sustainable Energy Reviews*, *Renewable Energy*, and *Solar Energy*. Study subject hotels, or in some cases, simulated hotels, were located in Australia, China, Europe, France, Germany, Greece, Hong Kong, India, Italy, Jordan, Korea, Poland, Portugal, Senegal, Singapore, Spain, Sweden, Tunisia, Turkey, and the United Kingdom.

Given the scarcity of prior research on hotels located in the U.S., a thorough review of the previously identified articles was performed to identify trends that might be predictive for the U.S. lodging industry. Three article clusters were identified. The cluster subjects were energy consumption in the broader context of environmental management (thirteen articles), renewable fuel use (eight articles), and feasibility studies of combined cooling, heating and power systems (CCHP) on existing or simulated hotels (eight articles). The three cluster subjects are loosely related to smart grid technologies because smart grid technologies have the potential to enable and/or enhance all of them - energy consumption monitoring, renewable fuel use, and CCHP system adoption – but the studies were not performed in the U.S.

2.2 Governments and Smart Grid Technology Adoption

The foundation of electric power everywhere is underpinned by political forces in the form of energy policy and regulatory action. These forces vary widely from country to country and region to region. Within a broad social context, governmental structure; relationships between energy suppliers and governing political forces; the balance of market forces and regulatory action; and energy prices are determining factors of the speed and efficiency of technology adoption. The evaluation of the affects of social contexts is outside of the scope of this study, but future studies may examine this important aspect of energy policy and regulation.

Articles in the smart grid technology space identify three primary players in the smart grid race - China, the EU, and the U.S. Examining the affects of governmental and regulatory structures on technology adoption is an important aspect of this research. The purpose of the observations presented here is to elucidate these affects; not to argue for or against, or judge their merits.

2.2.1 China

2.2.1.1 The Chinese Model

China has a single party political system with central governmental control. Chinese citizens vote at a local level but their votes carry just one message, the message of the ruling party. The party controls energy suppliers through state-owned mechanisms. China's energy suppliers are government-owned, centrally regulated, and subject to central mandates. The following description of the Chinese energy sector consists of excerpts from the DOE Energy Information Agency's (EIA) description of the sector (U.S. Energy Information Administration, 2010).

> The National Development and Reform Commission (NDRC) is the primary policymaking and regulatory authority in the energy sector. The government launched the National Energy Administration (NEA) in July 2008 in order to act as the key energy regulator for the country. The NEA, linked with the NDRC, is charged with approving new energy projects in China, setting domestic wholesale energy prices, and implementing the central government's energy policies, among other duties. The NDRC is a department of China's State Council, the highest organ of executive power in the country. In 2007, China outlined its energy policy goals in the Proposed Energy Law, though the law has yet to be enacted.
>
> Both electricity generation and consumption have increased by over 110 percent since 2000, and trade press reported that generation was up 20 percent in the first half of 2010 compared to a year earlier. EIA predicts total net generation to increase to 10,555 Bkwh by 2035, over 3 times the amount in 2009.
>
> China's electricity generation sector is dominated by five state-owned holding companies. These five holding companies generate about half of China's electricity. Much of the remainder is generated by independent power producers (IPPs), often in partnership with the privately-listed arms of the state-owned companies. While the generation sector has some market competition, the transmission and distribution sectors are heavily state-controlled. In 2002, the State Electricity Regulatory Commission

> (SERC) was established, which is responsible for the overall regulation of the electricity sector and improving investment and competition in order to alleviate power shortages.
>
> Wholesale and retail electricity prices are determined and capped by the NDRC which can limit the profit margin of generators. China raised end-user prices for all sectors except the residential sector by $0.04/kwh in late 2009. The latest power tariff changes were from June 2010 when the government raised rates for energy intensive industries by 50 to 100 percent in order to achieve energy efficiency goals for the year.
>
> Rapid growth in electricity demand this previous decade has spurred significant amounts of investment in new power stations. The government aims to merge 12 regional grids into three large power grid networks, namely a northern and northwestern grid. For the first time in 2008, the investment in the transmission grid was greater than that in the generation sector. The State Grid Company spent $44 billion in 2009 and plans to spend $33.3 billion in 2010 on grid investment, using some stimulus funds (U.S. Energy Information Administration, Country Analysis Briefs, 2010).

The State Grid Corporation of China (SGCC) is an organization that reports directly to the central Chinese government. SGCC has a "smart communities" guideline. The first smart community demonstration project in China was started in February, 2010. Just nine months later, the SGCC, in a press release dated October 25, 2010, described the completion of the project. The project consisted of 655 households and eleven buildings, and was the first project constructed under the guideline. It included a wide array of smart grid technologies – distributed solar power generating management, automatic electricity distribution, distributed power generation and energy storage – all managed by an "integrated network of the internet" and "realizing intellectual management of family power consumption." Home appliances that automatically read water, electric and gas meters record power consumption habits and support remote control. Power reliability is assured because the systems "detect malfunctions and reconstruct two-level network with fault self-recovery capability. It monitors the electricity transportation around the clock and tests power quality real time, which ensures 99.999% of reliable power supply" (State Grid Corporation of China, 2010).

It is clear from the EIA description of the Chinese energy sector and the roll out of China's first smart community project that the simple structure of the Chinese government; its state-owned energy suppliers; its power to mandate electricity prices, technology adoption in all socio-economic classes, and cyber security standards; allows China to quickly and efficiently adopt smart energy technologies.

2.2.1.2 Chinese Literature

Literature with Hong Kong hotels as subjects was combined with the Chinese literature because Hong Kong is a Special Administrative Region of China. Collectively, China and Hong Kong, with six articles (three from China and three from Hong Kong) were the most heavily represented country in terms of number of articles discovered in the literature review. Two of the six articles were studies of CCHP (Wang & Zhai., 2010) (Li, Shi, & Huang, 2008); one was a study of three chiller systems in Hong Kong hotels (Yu & Chan, 2005); one was about creative financing through performance contracting (Chan & Ho, 2006); one was about energy management in the context of environmental management (Penny, 2007); and one identified two factors – cooling degree days and number of unoccupied rooms – as determinants of electricity consumption in Hong Kong hotels (Chan, 2005).

2.2.2 The European Union

2.2.2.1 The EU Model

> The evolution of the European Union (EU) from a regional economic agreement among six neighboring states in 1951 to today's supranational organization of 27 countries across the European continent stands as an unprecedented phenomenon in the annals of history. The EU operates through a hybrid system of supranational independent institutions and intergovernmental made decisions negotiated by the member states (United States of America Central Intelligence Agency, 2010).
>
> EU membership places member countries under binding laws in exchange for representation in the EU's legislative and judicial institutions. Like U.S. states, EU countries have various mixes of privately-owned and publicly-owned energy providers. For example, Nordic countries have a mix of privately held and state-owned or municipally-owned electricity companies; France and Germany have state-owned mega-utilities" (Commodities Now, 2010).

However, unlike U.S. states, whose regulatory power resides at the state level, EU member countries are subject to central EU mandates. The U.S. does have a regulatory entity at the federal level, the Federal Energy Regulatory Commission (FERC), but FERC generally regulates interstate, not intrastate, energy activity. The EU's European Commission (EC) has the power to mandate central regulatory action, unlike in the U.S., where each state has its own public service utility commission that has jurisdiction over investor-owned electric utilities that serve about 71% of consumers (U.S. Energy Information Administration, 2010).

In 2009, the EC forced utilities in member countries to legally separate generation assets from transmission lines despite widespread national interest attitudes. The restructuring was intended to result in the realization of economies of scale and superior technology transfers. The specific goals were to increase the opportunities for alternative and greener energy suppliers while also enabling the flow of ‘smart’ technology. For example, economies of scale could be realized by building identical power generation plants or ordering a large number of wind turbines, and would give companies new-found leverage over the supply chain. A similar scenario is unlikely in the U.S. where states are not governed by a central entity such as the EC, each state follows its own separate mandates, and regulatory action often discourages collaboration between utilities. A collaborative effort of ten European utilities is now focused on building a super grid in the North Sea at a cost of $64 billion, a collaborative effort made possible through EU regulatory reform. The aim is to transport offshore wind power throughout the continent to diversify fuel sources and to bring down energy prices. Consequently, while the EU’s move spawned nationalistic turf wars, it also resulted in the deployment of innovative power generation technologies and encouraged efforts to ensure interoperability.

European utilities have launched smart technologies with system efficiency as the first priority by adopting distribution automation and voltage optimization to make electrical distribution systems more efficient. When these technologies prove fruitful, then the utilities will start implementing programs that require consumer involvement and behavior change (Berst, 2010). Contrast this approach with the U.S. consumer-centric roll-out of smart technologies such as smart meters and demand response, which require consumer marketing and consumer behavior change, a process in which efficiency is sacrificed as utilities and regulators wait for consumer consensus. Herein lies the parallel in the U.S. lodging industry – the industry has looked to guest energy habits to solve the energy management issue, when in fact, the solution is system efficiency enabled by smart technologies.

2.2.2.2 EU Literature

At least half of the twenty countries represented in the literature were EU countries. Nine member countries, France, Germany, Greece, Italy, Poland, Portugal, Spain, Sweden, and the United Kingdom were represented; and Turkey, a Candidate Country, was also included. More EU countries may have been represented but in a study by Bohdanowicz & Martinac (2007) country anonymity was a prerequisite for obtaining energy consumption information in hotels in twenty four European, but not necessarily EU, countries. Therefore, the anonymous countries from the study were represented in the literature review but they were not represented in the EU country count.

Renewable generation; carbon emissions; energy and water use; environmental protection programs and conservation practices; and the influence of geo-political, economic and socio-cultural contexts were the subjects of the EU literature.

Karagiorgas *et al*. (2006) examined applications of five renewable energy technologies (solar thermal, solar passive, solar PV, biomass and geothermal energy) in 200 hotels in five EU regions.

Mateus and Oliveira (2009) evaluated "the potential of integrated solar absorption cooling and heating systems for building applications" for a hypothetical hotel in Berlin, Germany; Lisbon, Portugal; and Rome, Italy.

Bechrakis, McKeough, & Gallagher (2006) "simulated the operation of a small, remote hotel primarily powered by a wind turbine and supported by a hydrogen energy system."

Desideri, Proietti, & Sdringola (2009) analyzed solar-powered cooling system refrigeration and air-conditioning applications for the heating and cooling demands of a hotel located in a tourist town in Italy.

Önüt and Soner (2006) assessed energy efficiency in thirty-two five-star hotels in the Antalya Region of Turkey and concluded that the most effective solutions for hotels in the region were solar energy applications and roof insulation systems.

Rosselló-Batle, Moià, Cladera, & Martinez (2010) determined that 78% of the energy use of hotels in the Balearic Island hotels, with an assumed fifty year lifetime, came "from the operation phase. It is during this phase where it is possible to achieve the biggest reductions in energy use, thanks to higher application of renewable energies and energy efficiency measures."

Xydis, Koroneos, & Polyzakis (2009) analyzed energy utilization and compared the exergy analyses of four Greek hotels to "gain awareness" into each hotel's efficiency.

Karagiorgas, Tsoutsos, & Moià -Pol. (2007) calculated the energy required to produce a lunch - 5.5 kWh/lunch - in a deluxe Greek hotel in 2003.

Piacentino and Cardona (2008) examined the application of a small-scale polygeneration system original design on a 1174 bed hotel in Rome.

Rubio-Maya, Uche-Marcuello, Martinez & Bayod- Rújula (2010) applied a model of a polygeneration plant fueled by natural gas, solar energy and gasified biomass to a Spanish tourist resort and concluded that the introduction of more efficient and cheaper renewable energy sources, and financial incentives in the form of avoided carbon emission bonuses, would allow distributed (decentralized) power generation.

Taylor, Peacock, Banfill, & Shao (2010) applied a computer model that simulated carbon emission reduction intervention methods, expected to be available by 2030, to two mid-price hotels, "with the aim of representing the most common UK hotel types." "A principle was adopted that interventions should not compromise guest comfort: almost all of the proposed measures will be invisible to guests when installed." The study dealt with technical feasibility, not economic feasibility, although cost effectiveness had an impact on the inclusion and ordering of some interventions. It is important to note that no mechanical cooling (A/C) was assumed for the hotels in the study, a circumstance that would not occur in most U.S. mid-price hotels. Solar thermal collectors were an intervention applied to water heating. Energy technologies, like smart grid technologies, were not included in the interventions. The authors concluded that 50% reductions in greenhouse gas emissions from hotels like the hotels in the study were technically feasible, with the main contributing intervention being wall insulation and triple glazing. Taylor (2010) concluded, "Achievement of an 80% emissions reductions target would require additional renewable or energy technologies to be used, such as ground-source heat pumps, solar voltaics and biomass," - all measures that are enabled by smart grid technologies.

In a study that assessed energy consumption, emissions, and potential energy savings of Hellenic non-residential building stock, including hotels, Gaglia *et al*. (2007) concluded that the most effective energy conservation measures were addition of thermal insulation of exposed external walls, installation of energy efficient lamps, installation of solar collectors for sanitary hot water production, installation of building management systems, replacement of old inefficient boilers, and regular maintenance of central heating boilers.

Erdogan and Baris (2007) investigated environmental protection programs and conservation practices of hotels in Ankara, Turkey, and recommended national and local policy changes.

Bohdanowicz & Martinac (2007) performed a case study of the energy and water use of 184 Hilton International and Scandic hotels (73 and 111, respectively) in twenty four European countries using data from 2004. Country anonymity was guaranteed in order to gain access to the study database. Based on the defined geographic zone of the study, it is likely that a majority of the countries were EU countries, but this could not be verified. For the purpose of examining the potential effects of smart grid technologies in the context of energy management, the discussion here will focus only on the portions of the study specifically related to energy consumption. Energy consumption was normalized in the study by dividing "total resource consumed" at each hotel by a "normalising factor (i.e. total floor area, total number of guest rooms, total number of guest nights sold)." Normalisation was required because the database used for the study did not have the capability to gather specific energy usage information about definable spaces. Hence, calculations resulted in estimates, not exact data reflective of real-time use. For example, Bohdanowicz and Martinac (2007) stated, "As most of the high tail Scandic hotels also offer large conference facilities used by day-guests (i.e., "non-sleepers"), the energy utilisation per guest-night (based on "sleepers") was somewhat overestimated." For academic and practical purposes, the need for estimations will be eliminated as 'smart' energy management information systems collect data reflecting real-time energy usage of definable spaces and identifiable guests. Electricity was the dominant energy carrier in the hotels in the study, and "About half the energy [in] these hotels is used for space conditioning and DWH [domestic water heating] (51% for the upscale hotel [Hilton] and 52% for the mid-market brand [Scandic])" (Bohdanowicz & Martinac, 2007). The costs associated with these figures is staggering, but more importantly, there is tremendous financial opportunity in innovative energy management via technology adoption. It is interesting to note that Hilton International is a U.S. based company, but the U.S. was not the geographical subject area of the study.

Bohdanowicz (2007) investigated "the influence of geo-political, economic and socio-cultural context of a country on the environmental attitudes and pro-ecological initiatives" in the Swedish and Polish hotel industries with an email based survey. Geo-political, economic and socio-cultural influences also apply to technology adoption, and therefore, are suggested for future smart grid technology research. Bohdanowicz argued that there were

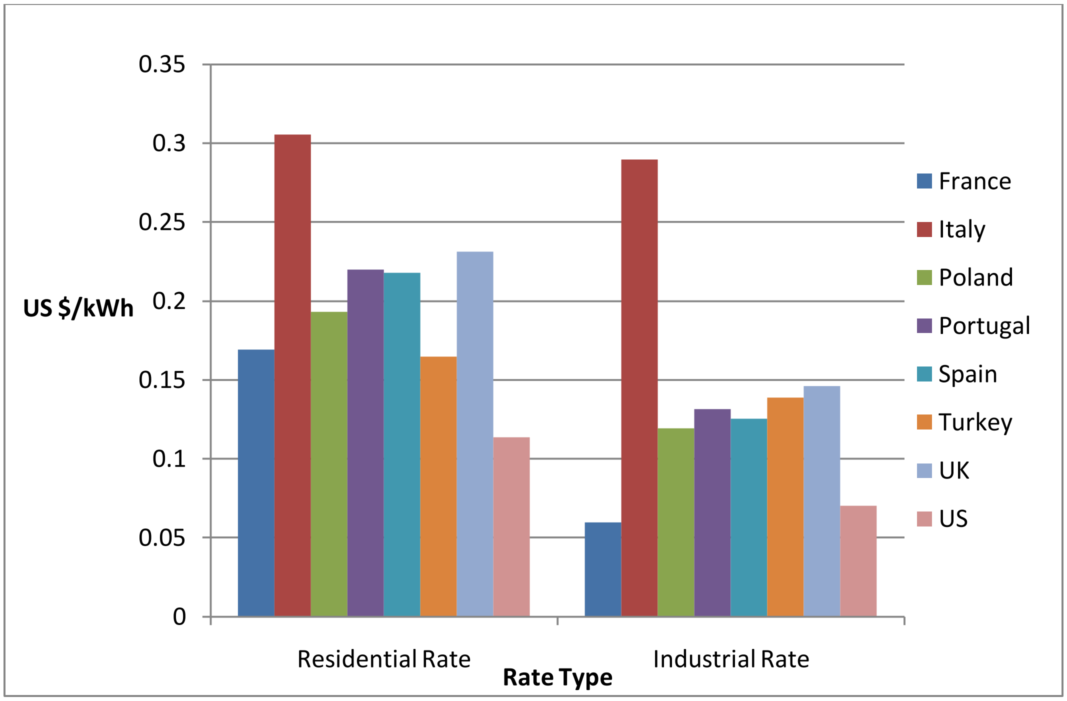
> . . . two major directions that need to be followed when introducing environmental sustainability into the hotel industry. The first involves incorporating responsible technical and behavioral practices in the sector. The second highlights the necessity of initiating greater demand for "green" practices from the customers (Bohdanowicz, 2007).

Bohdanowicz did not attach priorities to the two directions she recommended. The evaluation and prudent adoption of smart grid technologies is an integral part of incorporating responsible technical and behavioral practices in the sector. It must be the first priority. The second direction, initiating greater demand for "green" practices from guests, will be more fruitful when the technologies to accurately assess guest energy consumption have been adopted.

2.2.3 The United States of America

2.2.3.1 The U.S. Model

U.S. governmental framework sets the stage for a consumer-centric society, where consumer behavior is the first outlet explored to create change, technological or otherwise. U.S. citizens live in a society where individuality is valued above all else. Consequently, many U.S. voters vote for candidates they believe have the ability to guarantee perceived entitlement to cheap energy. Figure 8 is an illustration of residential and industrial electricity costs, drawn from statistics published by the International Energy Agency (IEA) (International Energy Agency, 2010) in the U.S. and in EU countries represented in the literature, except Germany, Greece, and Sweden. Electric utilities in Germany, Greece and Sweden are state-owned. These countries do not appear in the chart because statistics were not available for them in the IEA report. Electric energy has long been affordable in the U.S., as illustrated in Figure 8. The U.S. enjoys the lowest electricity costs, with the exception of French industrial electricity. France's electricity market is being reformed under a program coined "NOME," an acronym for "new organization of the electricity market."



Data Source: International Energy Agency 2009
Key World Energy Statistics

Figure 8: Residential and Industrial Electricity Costs in the U.S. and Selected EU Countries

U.S. utilities grapple with regulatory action at the state level which can change relatively frequently as voters routinely swing the political pendulum to secure perceived entitlement to cheap energy. This framework creates a prohibitive atmosphere for collaboration and efficient technology transfer.

In 2007, the latest year of statistics available from the EIA, there were more than 3,273 traditional electric utilities in the United States. Here is a descriptive excerpt of U.S. electric utilities from the EIA:

The more than 3,273 traditional electric utilities in the United States are responsible for ensuring an adequate and reliable source of electricity to all consumers in their service territories at a reasonable cost. Electric utilities include investor-owned, publicly-owned, cooperatives, and Federal utilities. Power marketers buy and sell electricity, but usually do not own or operate generation, transmission, or distribution facilities. Utilities are regulated by local, State, and Federal authorities, and in the case of many electric cooperatives, by their Board of Directors.

Interstate sales of electricity on the wholesale market and by public utilities (e.g., investor-owned utilities, power marketers, independent power producers, and non-exempt electric cooperatives) are subject to regulation by the Federal Energy Regulatory Commission (FERC). FERC also regulates interstate transmission service provided by transmission-owning public utilities. In addition to regulating transactions in interstate commerce, FERC licenses hydroelectric facilities on navigable waterways. Licensing the construction and operation of nuclear power plants, safety and nuclear waste disposal management is under the jurisdiction of the Nuclear Regulatory Commission. Retail sales, and unbundled distribution service provided by investor-owned utilities are subject to State regulation. In some States, municipal utilities and electric cooperatives rates are also subject to State regulation. Approval of the construction of most power plants and transmission line construction is generally regulated by the States.

State public service commissions have jurisdiction primarily over the large, vertically integrated, investor-owned electric utilities that own more than 38 percent of the Nation's generating capacity and serve about 71 percent of ultimate consumers. There are 210 investor-owned electric utilities, 2,009 publicly-owned electric utilities, 883 consumer-owned rural electric cooperatives, and 9 Federal electric utilities. A small amount of electricity is sold by generating facilities directly to end use customers. At least 6 States regulate cooperatives, and at least 7 States regulate municipal electric utilities; many State legislatures, however, defer this control to local municipal officials or cooperative members (U.S. Energy Information Administration, 2010).

Contrast this descriptive quagmire with the simplicity of the Chinese and EU regulatory models, and it is easy to see how the adoption of new technologies gets bogged down in the U.S. system.

A simplified description of the regulatory activity surrounding SmartGridCity (SGC) in Boulder, Colorado, illustrates how complicated and time consuming it can be to make technological progress in the U.S.

In January, 2008, Xcel Energy announced it was looking for a city in its eight-state territory in which to build a SGC. In March, 2008, Boulder, Colorado was chosen as the location for SGC, funded by a consortium of companies and regulated by the Colorado Public Utility Commission (CPUC). In November, 2009, Xcel Energy, on behalf of the consortium, reached a settlement agreement with the CPUC that allowed the cost of SGC to be recouped from ratepayers. In December, 2009, the CPUC approved the agreement, and issued a requirement for Xcel Energy to file for a Certificate of Public Convenience and Necessity (CPCN) to obtain approval to construct transmission lines for SGC. In March, 2010, Xcel filed for a CPCN.

To illustrate the complexity of obtaining a CPCN, Figure 9 is a CPCN description from the Southern Colorado Transmission Improvements Site (Southern Colorado Transmission Improvements: A Certificate of Public Convenience and Necessity, 2011):

A Certificate of Public Convenience and Necessity

The Colorado Public Utilities Law (Colorado Revised Statutes § 40-1-101, et seq.) and the rules of the Colorado Public Utilities Commission (CPUC) (4 Code of Colorado Regulations 723-3) require that an electric utility seeking to construct and operate an electric transmission line must first obtain a Certificate of Public Convenience and Need (CPCN) for the transmission line unless the CPUC determines that construction of the line is in the ordinary course of business in which case, a CPCN is not needed for the transmission line project.

In the case of a proposed electric transmission line, a CPCN application must include the following information:

- A statement of facts showing how the proposed transmission line is required for the public convenience and necessity
- A description of the proposed transmission line
- The estimated cost of the proposed transmission line
- The anticipated construction time frame and in-service date for the transmission line
- Maps showing the general area of the line, population centers, major highways, and county and state boundaries
- Electrical diagrams of the proposed transmission line
- Information on alternatives studied and the criteria used to rank such alternatives
- A report on prudent avoidance measures relating to exposure to magnetic fields associated with the proposed transmission line
- Information concerning projected audible noise levels associated with the transmission line and cost-effective mitigation measures

This information is considered by the CPUC when determining the need for the proposed transmission line. It is important to note that the CPCN process does not decide the final location of the transmission line. The final location and alignment of the transmission line is determined through a separate and extensive federal, state, and local government siting and permitting process.

Figure 9: A Certificate of Public Convenience and Necessity

A review of the State of Colorado Department of Regulatory Agencies PUC (2011) Application for SmartGridCity CPCN revealed that the CPCN, applied for on March 10, 2010, had over 320 documents on the docket, and the CPCN Status was listed as "Pending Compliance."

In August, 2010, Xcel reached a new agreement with the CPUC. A cap was placed on SGC cost recovery from ratepayers and the CPCN was allowed. In October, 2010 a judge recommended that the CPUC adopt the August, 2010 agreement. In January, 2011, the CPUC rejected the recommendation and reduced the consortium's cost recovery amount by 38%.

There was much speculation surrounding the CPUC action. Thousands of pages have been written about it, and internet smart grid circles have been buzzing ever since the decision was made. For the purposes of this research, the extremely simplified summary of the trials and tribulations of a U.S. SGC, provided here, serve to illustrate the complexities of the U.S. regulatory system and contrast it with the simplicity and efficiency of the Chinese and EU systems.

SGC has been forty months in the making. Nonetheless, where there is a will; there is a way. An Xcel SGC representative provided this SGC update on April 22, 2011:

> The broadband over powerline (BPL) network is built out to serve virtually all Boulder premises (46,701 premises, to be exact). All of these premises are impacted from the "grid-side," meaning they should be experiencing increased reliability, reduced outage duration, reduced voltage problems, etc.
>
> 23,000 homes have smart meters. All Xcel Energy residential customers have access to an online account management portal (MyAccount), but

these 23,000 customers have the added benefit of being able to see their usage data broken down in 15-minute increments if they choose to use the portal.

86 commercial buildings have smart meters installed (and access to an online portal to view usage as well).

4,361 residences have elected to participate in the new, dynamic pricing pilot.

We hope to get 1,850 homes in Boulder equipped with in-home energy management devices in the next several months for our upcoming in-home smart device pilot.

The participants in the IHD pilot have been/will be chosen on a voluntary basis. A subset of them (~1,250 homes if possible) will also be participants in our pricing pilot that is currently underway. We actually deployed five systems from one manufacturer a couple of weeks ago, and assuming the initial tests go well, we'll continue deploying that particular system over the next few months. Additionally, we have another couple of systems from other manufacturers currently being tested and will deploy those once they have passed our security and functionality tests.

Undeterred by significant hurdles inherent in the U.S. regulatory structure, a U.S. utility's tenacious efforts are bringing technological change, in the form of smart grid technology adoption, to Boulder.

2.2.3.2 U.S. Literature

Notwithstanding the absence of energy management related studies in U.S. hotels in the literature, there is evidence that progress has been made. A review of industry roundtable discussions revealed that U.S. lodging companies have developed custom and, in most cases, proprietary systems that enable hotel managers to record energy consumption data on-site. System software compares best practices at similar hotels and provides action items to boost efficiency.

Other systems provide measurement tools that accurately quantify energy usage at property and defined user levels, allowing energy managers to provide accurate reflections of how operational behaviors translate into costs. The capacities of these systems to better manage energy usage may be enhanced with system integration of smart grid technologies.

2.2.4 Literature Representation in a Global Energy Context

> The International Energy Agency (IEA) is an intergovernmental organisation which acts as energy policy advisor to 28 member countries in their effort to ensure reliable, affordable and clean energy for their citizens. Founded during the oil crisis of 1973-74, the IEA's initial role was to co-ordinate measures in times of oil supply emergencies. Energy security remains a key priority, but has expanded beyond concerns about oil supplies to include natural gas and electricity (International Energy Agency, 2010).

Figure 10 is a matrix that includes the U.S. and countries represented in the literature. The IEA has a website, "IEA in Chinese," but China is not a member of the IEA. China is represented in the literature. Nine EU member countries (France, Germany, Greece, Italy, Poland, Portugal, Spain, Sweden, and the United Kingdom) and one EU candidate country (Turkey) are verifiably represented in the literature. All EU member and candidate countries represented in the literature are IEA members. The U.S. is an IEA member. The U.S. is not represented in the literature.

Country*	Represented in Literature	IEA Member	EU Member
Australia	X	X	
China	X		
France	X	X	X
Germany	X	X	X
Ghana	X		
Greece	X	X	X
Hong Kong	X		
India	X		
Italy	X	X	X
Jordan	X		
Republic of Korea	X	X	
Poland	X	X	X
Portugal	X	X	X
Senegal	X		
Singapore	X		
Spain	X	X	X
Sweden	X	X	X
Tunisia	X		
Turkey	X	X	X**
United Kingdom	X	X	X
United States		X	

*Some EU countries that may have been represented in the literature may not appear because anonymity was a prerequisite for obtaining hotel energy consumption information in 24 European countries in Bohdanowicz & Martinac (2007). It is likely, although not verifiable, that the 10 EU countries in the chart were included in the study.

** EU candidate country

Figure 10: Country Matrix

Chapter 3

RESEARCH METHOD AND DESIGN

3.1 The Delphi Technique

"In ancient Greece, Delphi was the site of the most important oracle, at the temple of Apollo on the slopes of Parnassus. This oracle was famous for its ability to forecast the future (as well as being somewhat cryptic in its prognostications). In the modern academic arena, Delphi is now known as a research method named after this mystical oracle" (Faucher, Everett, & Lawson).

"The Delphi survey technique was developed in the 1950s by two research scientists working at The Rand Corporation, Olaf Helmer and Norman Dalkey. They developed the procedure as a tool for forecasting future events using a series of intensive questionnaires interspersed with controlled-opinion feedback" (as cited in Custer, Scarcella, & Stewart, 1999). The technique was used by the American military to forecast the impact of technology on warfare. More recently, it has been widely used for health care and business forecasting. For this research, the Delphi method was applied to forecast the future of smart grid technology in the U.S. lodging industry, a combination of technology and business.

The Delphi technique begins with an open-ended questionnaire that is given to a panel of selected experts to solicit specific information about a subject or content area. In subsequent rounds of the procedure, participants make changes to the phrasing or substance of the items and rate the relative importance of individual identified items. Through a series of rounds (typically three) the process is designed to yield consensus (Custer *et al*., 1999).

The Delphi method dictates that participants are experts. To determine the characteristics of study panel members and the optimal number of panel members, guidance came from and Powell (2003) and Rowe & Wright (1999).

> It has been noted that heterogeneous groups, characterized by panel members with widely varying personalities and substantially different perspectives on a problem, produce a higher proportion of high quality, highly acceptable solutions than homogeneous groups (Delbecq et al. 1975). This finding is strongly supported by Rowe (1994) who suggested that experts be drawn from varied backgrounds in order to guarantee a wide base of knowledge. Murphy et al. (1998) conclude that diversity of expert panel membership leads to better performance as this may allow for the consideration of different perspectives and a wider range of alternatives (Powell, 2003).

For the reasons stated by Powell, experts for this study were not strictly restricted to lodging companies. To tap different perspectives and provide a wide knowledge base, experts from entertainment industry resorts (one expert); gaming industry resorts (one expert); non-entertainment and non-gaming industry lodging and resorts (five experts); lodging industry energy technology providers (two experts); and lodging industry energy management and sustainability consultants (three experts) participated in the study. This approach enhanced the study, particularly in the sections where experts identified, and commented on, benefits, challenges and risks of smart grid technologies. Although experts identified many of the same smart grid technologies in the first round, their varied backgrounds reflected different perspectives in the second round, which added valuable insights to the study; provided a wide range of comments and clarifications; and enhanced the benefit experts received from exchanging ideas with others.

In Delphi studies with professional (versus student) experts from a *Summary of the methodological features of Delphi in experimental studies* (Rowe & Wright, 1999), Dalkey and Helmer (1963) was heavily weighted when considering the characteristics of the study experts because the study intent (forecasting the effects of technology) most closely matched the intent of this research. Economists, electronic engineers, and systems analysts participated in Dalkey and Helmer (1963) (Rowe & Wright, 1999). Expert panel members for researching smart grid technologies have backgrounds in finance, electrical engineering (some with Professional Engineering [P.E.] licenses), sustainability analysis, information communication technology, energy technology design, energy technology procurement and energy technology consulting. All experts hold executive or partner positions in their respective companies and are responsible for energy, environmental, and sustainability management, except for a Sustainability Analyst who responded on behalf of an executive charged with managing corporate energy and environmental services.

To provide an enhanced description of study experts and the companies they represent, without compromising their anonymity, I offer these observations. Four study experts have participated in Cornell Sustainability Roundtables. Two experts are members of the American Hotel & Lodging Association (AHLA)

Green Task Force. Three of the top six hotel companies in the world, ranked by number of rooms, are represented. One of the world's leading gaming hospitality companies is represented, as is one of the leading entertainment companies. Cutting-edge energy technology providers are represented the study. Study consulting company experts bring decades of experience in the top ranked lodging companies and provide expert advice and guidance to all segments of the lodging industry. Study experts also represent admired historic, as well as newly-built, properties that have garnered international, national, state and local awards for social, environmental and economic sustainability. The properties they represent consistently appear on the *Condé Nast Traveler Gold List* and the top twenty-five tripadvisor.com Travelers' Choice® awards.

Powell (2003) stated, "There is very little actual empirical evidence on the effect of the number of participants on the reliability or validity of consensus processes." From Rowe & Wright (1999), seven experts participated on the study panel in Dalkey & Helmer (1963); Best (1974) had a panel size of fourteen; Spinelli (1983) had a panel size of twenty and Brockoff (1975) did a Delphi technique comparison with five, seven, nine and eleven panel members. The average panel size in these studies was ten. Brockhoff (1975) suggested that for forecasting questions, groups with eleven participants were more accurate in their predictions than larger groups. Another important consideration in Delphi studies is the potential loss of experts during study rounds. Consequently, I set a target range of nine to thirteen study experts. The goal was to achieve the upper end of the range initially, so that the loss of participants would not compromise study prediction accuracy. Twenty-six experts were invited.

The study was conducted by email. Each potential participant was sent a letter of invitation containing a description of the study (Appendix B). Invitations began to be emailed on January 12, 2011. Twelve potential participants accepted; one accepted but deferred, to the company's energy technology provider expert who had previously accepted an invitation, before the first study round began; three (including two of the top seven hotel companies in the world, by number of rooms) declined after failed attempts to find potential participants familiar with smart grid technology in their organizations; three declined; seven did not respond. All twelve experts who ultimately accepted invitations participated in all study rounds.

Consistent with the Delphi methodology, participant anonymity was maintained, which allowed participants to freely express their opinions without the interference of peer dynamics. There were three rounds in the study. All rounds consisted of the same seventeen questions, in similar formats, to provide consistency. An opportunity for study experts to make general comments was provided at the ends of rounds one and two.

3.2 Round One

The purpose of the first round was to collect information about smart grid technologies from study experts. The instrument consisted of an open-ended questionnaire (Appendix C). Participants were asked to respond to ten questions if smart grid technologies had not been adopted and to seventeen questions if smart grid technologies had been adopted. Study experts were given the option to express additional comments at the end of round one. First rounds were sent to study experts within twenty-four hours of receipt of study invitation acceptance. All first rounds were returned by February 18, 2011.

3.3 Round Two

The purpose of the second round was to provide each expert with the opportunity to contribute additional ideas, clarifications, and elaborations based on the initial survey responses. An email letter (Appendix D) was sent to study experts with the second round instrument (Appendix E) attached. The second study round included all first round responses as submitted by participants with the exceptions of duplicate responses and identifying information. That is, if the same response to a question appeared multiple times in the first round, it appeared with that question just once in the second round. Identifying information, such as energy technology system and company names, was substituted with "XXXXX." Smart grid technology adoption is not a prerequisite for smart grid technology knowledge. Consequently, all participants were invited to respond to seventeen questions in the second round. Study experts were given the option to express additional comments at the end of round two. Experts took advantage of the opportunity to engage in collaborative discourse which provided enhanced "conversation" and an extra measure of clarity. Second rounds were sent to study experts on February 18, 2011. Eleven of twelve second rounds were returned by March 17, 2011. The remaining second round was returned on March 24, 2011. It was reviewed for potential impact on the third study round. It contained some identifying information that could not have been included in the third round (to protect anonymity), and the contents would not have altered the third round, had it been received by March 17, 2011.

.

3.4 Round Three

The purpose of the third study round was to reach consensus by ranking issues identified and clarified in the first and second rounds. An email letter (Appendix F) was sent to study experts to introduce them to the third round instrument. A survey follow-up email (Appendix H) was sent immediately after the third round survey instrument link was sent.

Brancheau, Janz, & Wetherbe (1996) used a Likert scale to rank issues by statistical mean in a Delphi study to forecast key issues in information systems management. The study followed methods used in four previous studies of the same topic. A review of a *Summary of the methodological features of Delphi in experimental studies* (Rowe & Wright, 1999) revealed that mean values were commonly used in Delphi feedback.

A five point Likert scale was used for this research. Point definitions were carefully chosen to reflect the intent of this research and they varied, depending on the question (Appendix G). Third round surveys were sent on March 21, 2011 to the eleven study experts whose second rounds had been submitted. The remaining survey was sent to the remaining study expert on March 24, 2011, the date he submitted his second round. All third round surveys were returned by April 1, 2011.

Chapter 4

RESULTS AND DISCUSSION

4.1 Results Introduction

In this chapter, each research question, as it appeared in Chapter 1, is followed by the third round question, as it appeared in the survey. Items identified by study experts are listed in a table in descending order, from the highest mean rating (MR) to the lowest MR, along with standard deviations (SDs). Number of study experts (N) = 12 for each question. A discussion of results appears at the end of each question section. Technologies identified as smart grid technologies by Delphi study participants appear in **bold** type. In an effort to allow readers to "hear" study expert voices, expert insights appear at the end of this chapter.

4.2 Results

Question 1. What smart grid technologies are industry experts aware of that may apply to the lodging industry?

Study participants identified the following technologies as smart grid technologies that may apply to the U.S. lodging industry.

Please choose the best description of how useful you believe each technology is in the U.S. lodging industry.

Table 1: Delphi Third Round Question 1 Results

Rank	Identified Smart Grid Technologies	Mean Rating	Standard Deviation
1	Energy management systems	4.50	0.67
2	Energy information systems	4.25	0.75
3	Sub-metering	4.17	0.83
4	Demand response technology/peak demand reduction	4.00	0.74
5	End-user (guest room) energy management technologies	3.92	0.90
6	Property management systems	3.92	1.08
7	Smart meters	3.83	0.94
8	Load shifting	3.75	0.87
9	Digital, two-way communications with utility	3.58	1.00
10	Data acquisition servers	3.50	1.17

The top-ranked technology, **Energy management systems**, had the lowest SD in the table, indicating that there was firm agreement among study experts about the usefulness of the systems.

Despite the appearance of current industry focus on guest energy consumption habits, the usefulness of **End-user (guest room) energy management technologies** ranked fifth. The results may parallel priorities study experts place on smart grid technology adoption, and highlight the perceived limited potential that exists in controlling guest energy consumption at present.

The rank of ninth for **Digital, two-way communications with utility** set a precedent for experts' perceptions of this critical element of smart grid technology adoption throughout the study. Experts were aware of the technology, but did not rank it among the most useful.

Question 2. How did the identified smart grid technologies come to the attention of lodging industry experts?

Study participants identified the following methods by which they became aware of smart grid technologies.

Please choose the level of effectiveness that best describes your experience with each method.

Table 2: Delphi Third Round Question 2 Results

Rank	Smart Grid Technology Awareness Methods	Mean Rating	Standard Deviation
1	Personal contacts in the lodging industry	3.50	0.80
2	Individual research - Internet search	3.50	0.90
3	In-house staff knowledge base	3.25	1.48
4	Energy information technology vendors	3.08	1.24
5	Interaction with local utility personnel	3.08	1.31
6	Individual research - print articles and publications	3.00	1.13
7	Energy information technology industry trade shows	2.92	1.08
8	Inquiries from lodging properties/companies	2.83	1.27
9	Utility industry articles and publications	2.75	1.29
10	Lodging industry publications	2.67	0.98
11	Energy information technology industry joint projects	2.67	1.30
12	Lodging industry trade shows	2.58	1.00
13	Public utility commission filings	2.50	1.17
14	Local utility news	2.33	1.23
15	Local general news	2.00	1.04

The SDs of the two top-ranked awareness methods, **Personal contacts in the lodging industry** and **Individual research - Internet search**, 0.80 and 0.90 respectively, indicated that industry experts agreed that they first rely on peer interaction and their own discriminating research before they look to other industry sources, such as utility companies and energy technology providers, in their quest for information about smart grid technologies. Moreover, the third ranked awareness method, **In-house staff knowledge**, ranked above **Energy**

information technology vendors (fourth) and **Interaction with local utility personnel** (fifth). The rankings indicate that utility companies and energy information technology providers can improve their efforts to educate the lodging industry about smart grid technologies.

Question 3. What smart grid technologies have been adopted in the lodging industry?

Study participants identified the following smart grid technologies as having been currently adopted in their lodging properties, companies, or client companies.

Please choose the best description of the usefulness of each technology in the U.S. lodging industry.

Table 3: Delphi Third Round Question 3 Results

Rank	Adopted Smart Grid Technologies	Mean Rating	Standard Deviation
1	Enterprise energy management systems that control facility HVAC and lighting based on time schedules and temperature setpoints	4.58	0.67
2	Technologies that provide load shedding capabilities	3.92	0.90
3	Technologies that provide demand response capabilities	3.83	0.83
4	Technologies that provide net-metering capabilities	3.67	0.89
5	End-user (guest room) energy management systems with peak demand reduction response capabilities	3.58	0.90
6	Gas line telemetry allowing properties to go off utility pricing	3.58	0.90
7	Remote, wireless, monitoring equipment	3.58	1.08
8	Technologies that provide daylight harvesting capabilities	3.42	1.08
9	Smart meters capable of measuring consumption in 15 minute intervals	3.42	1.31
10	Custom, web-based, energy information systems that provide feedback to customers on their energy usage	3.25	1.22
11	Smart meters with two-way communications with utility companies	3.08	1.16

Technologies that appeared in Question 1 (technologies that study experts were aware of), and in Question 3 (adopted technologies) were **energy management systems**, **end-user (guest room) energy management systems**, **smart meters**, **two-way communications with utilities**, **demand response**, **energy information systems**, and **load shifting/shedding**.

Energy management systems occupied the top spot and had the same SD (0.67) on both tables, indicating study experts were very much in agreement with other experts' assessments of the usefulness of these systems. **End-user (guest room) energy management systems,** ranked fifth in both tables, had the same SD (0.90), confirming study expert prioritization of these systems. **Smart meters** ranked seventh in Table 1 and ninth in Table 3, indicating that experts agreed that smart meters are not very useful. It is clear that **Digital, two-way communications with utility** in Table 1 and **Technologies capable of providing two-way communications with utility companies** in Table 3 were considered among the least useful by study experts, ranking ninth in Question 1, and eleventh in Question 3.

There was disagreement reflected in the tables for **Demand response,** ranked fourth and tenth; **energy information systems**, ranked second and tenth; and **load shifting/shedding**, ranked eighth and second respectively.

Technologies that study experts were aware of (Question 1) but were not identified as adopted technologies (Question 3) were **Data acquisition servers, Sub-metering**, and **Property management systems**. **Data acquisition servers** and **Sub-metering** are components of **Custom, web-based, energy information systems that provide feedback to customers on their energy usage**, ranked tenth of eleven of adopted technologies. **Property management system** attributes appeared to be best understood by energy technology provider and consultant experts in the study. For example, a study expert who represented an industry technology provider stated, "In hotels, the integration of these systems to

Energy Management Systems can significantly enhance the savings available. Rooms that have not been rented can have deeper temperature setbacks than rooms that are rented but unoccupied. Furthermore, in low season, groups of rooms can be put into "hibernation" to minimize energy consumption associated with HVAC or lighting equipment;" while another study expert who represented a company recognized for excellence in innovative energy management commented, "don't know much about these systems." Therefore, it is possible that **Property management systems** were considered part of the top-ranked technology, **Enterprise energy management systems that control facility HVAC and lighting based on time schedules and temperature set points**, by the majority of study participants.

Technologies that appeared in adopted technologies (Question 3) but were not in identified technologies (Question 1) were **Technologies that provide net-metering capabilities**, **Gas line telemetry allowing properties to go off utility pricing**, **Technologies that provide daylight harvesting capabilities**, and **Remote, wireless, monitoring equipment**. An explanation for the enhanced information in Question 3 may be that more details occurred to study participants as they considered successful technology adoption.

Question 4. What are the perceived tangible benefits of adopted smart grid technologies in the lodging industry?

Study participants identified the following tangible benefits of currently adopted smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 4: Delphi Third Round Question 4 Results

Rank	Adopted Smart Grid Technologies Tangible Benefits	Mean Rating	Standard Deviation
1	Lower energy costs as a result of better load management	4.42	0.51
2	Income received from utility company incentives for participation in peak load reduction programs	4.17	0.94
3	Lower energy costs as a result of the ability to track and benchmark energy use	4.08	0.90
4	Lower energy costs as a result of end-user (guest room) energy management systems	3.92	0.90
5	Lower energy costs as a result of time-of-use management	3.75	0.62
6	Reduced payback periods for energy management systems	3.75	0.87
7	Lower energy costs as a result of peak demand shaving strategies	3.58	0.67

Lower energy costs ranked first, third, fourth, fifth and seventh as tangible benefits of smart grid technology adoption. This is not surprising, but what is interesting about the rankings is that study experts were discerning about *how* the technologies could achieve lower costs. Study experts made numerous comments in the first and second rounds about the issue of guest satisfaction potentially being compromised as a result of reduced energy use during peak demand times. A first round contribution, “The technologies that apply to the lodging industry are centered around demand reduction or load shifting, prompted the second round response "... guest satisfaction can tie the hands of even the best of Demand Response technology and intentions…if a guest wants an air conditioned room down to 60 degrees, the hotel needs to be able to provide it." Peak demand times often translate into peak electric rates, and high time-of-use rates, both determined by utilities. This is often when guests require energy the most; demand is at peak levels. So, while **peak demand shaving** is an option, it may not be the most productive strategy, as evidenced by the fact that study experts ranked it seventh, or last, among tangible benefits of adopted technology.

End-user (guest room) energy management systems appeared as a means to achieve lower energy costs, but again, these systems appeared lower (fourth) in the rankings than property controlled methods. Experts continued to demonstrate that the greatest potential for energy savings lies in taking action in situations they control such as **load managing** and **tracking/benchmarking**, which is why these two strategies were ranked first and second respectively.

The appearance of incentives, **income received from utility companies for participation in peak load reduction programs**, in the study set off a buzz in the conversation. "DR provides financial incentives for businesses to reduce or shift electricity use in response to power grid reliability needs or, in some regions, high electricity prices" (Yoshimura, 2006). DR programs are available, as real-time metering, web, and remote control technologies make it a viable option. Some utility companies are soliciting the lodging industry by advertising in lodging trade magazines. For example, in the September, 2010 issue of *Lodging Hospitality*, Pacific Gas and Electric (PG & E) placed a full page ad focused on

DR programs. The ad contained a web address dedicated specifically to lodging companies. Incentives can be earned with PG&E's Technical Audit/Technology Incentive program for the identification and installation of demand response enabling equipment. In theory, this program sounds like a good option. Study participants clearly perceived **Income received from utility company incentives for participation in peak load reduction programs** as an important tangible benefit of smart grid technology adoption as evidenced by the ranking (second) but at the same time, **peak demand shaving** or **peak load reduction** was a concept they were not entirely comfortable with because of perceived negative impact on guest satisfaction. This conflict is reflected in the fact that the SD for incentives was the largest (0.94) of all identified tangible benefits. Additionally, perceptions of the size of incentives varied widely between study experts as evidenced by comments made in the first and second rounds. One expert said, "Utilities are paying hotels for choosing to participate in peak demand reduction (tens of thousands of dollars/year) and are likely to offer enhanced participation fees for more timely response" but a panel expert who represented a consulting company painted a more realistic industry picture when he responded ". . . absolutely true, and wonderful in theory, but most of these high payments are made only when a utility/ISO [independent system operator] made it through a period without having to call for a curtailment. Unless hotels are equipped with "qualified distributed generation" systems, payments simply don't get that big…but it has been hyped to be much bigger." This example illustrates the benefit of study expert panel diversity.

Question 5. What are the perceived intangible benefits of adopted smart grid technologies in the lodging industry?

Study participants identified the following intangible benefits of currently adopted smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 5: Delphi Third Round Question 5 Results

Rank	Adopted Smart Grid Technologies Intangible Benefits	Mean Rating	Standard Deviation
1	Ability to monitor progress and track improvement	4.50	0.67
2	Environmental conservation	4.42	0.51
3	Sustainability/ public relations	4.00	0.85
4	Opportunity to advertise green efforts thus attracting individual travelers who prefer those types of properties	3.92	0.79
5	Opportunity to advertise green efforts thus attracting groups who prefer those types of properties	3.92	0.79
6	Guests may be stimulated to consume less when they can compare their consumption against other rooms or averages	3.58	0.90
7	More reliable overall service from utility companies because of greater efficiencies in managing generation and distribution	3.50	0.67
8	Better comfort conditions for guests	3.42	0.79
9	Better comfort conditions for employees	3.25	0.62

In this question, the lowest SD (0.51) appeared in **Environmental conservation.** This important intangible benefit of smart grid technology adoption was ranked second, portraying study experts as responsible corporate and world citizens.

The intangible benefits of the **Ability to monitor progress and track improvement**, **Environmental conservation**, **Sustainability/ public relations** and the **Opportunity to advertise "green" efforts** ranked higher than **Guests**

may be stimulated to consume less when they can compare their consumption against other rooms or averages and **More reliable overall service from utility companies because of greater efficiencies in managing generation and distribution**. The potential for energy savings from end-user (guest room) technologies, with various guest motivational considerations, was ranked sixth in **Guests may be stimulated to consume less when they can compare their consumption against other rooms or averages.** Other end-user technologies had been ranked sixth two other times at this early stage of the study, demonstrating that study participants prefer to rely on factors they control, rather than factors guests and energy suppliers control.

Question 6. Which adopted smart grid technologies have the greatest benefits in the lodging industry?

Study participants identified the following currently adopted smart grid technologies as having the greatest benefits in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 6: Delphi Third Round Question 6 Results

Rank	Adopted Smart Grid Technologies Greatest Benefits	Mean Rating	Standard Deviation
1	Energy management systems	4.50	0.52
2	Remote monitoring technologies	3.83	0.83
3	Technologies capable of identifying detailed levels of peak vs. non-peak consumption	3.58	0.79
4	Technologies that provide scheduled load shedding	3.58	0.79

Study experts confirmed in this question that they believed **energy management systems** have the greatest benefits in the industry with a relatively low SD of 0.52 and a MR of 4.50, significantly above other MRs in the Table. Comments from all segments of the panel resonated on the perceived value of EMS; from an expert who represented an industry consulting company

> All full-service hotels SHOULD utilize an EMS. The nature of a full service hotel is that while certain areas of the property are being fully utilized (ball rooms, meeting rooms, spas/pools, restaurants, etc.), the guest rooms aren't…and vice versa. A good energy management system can take advantage of the natural ebbs and flows of the guests, and streamline overall energy use on a minute-by-minute basis;

from an expert who represented an energy technology provider "There is good market acceptance of this type of system. The ROI can be as little as 2 years and many utilities offer rebates that motivate the purchase of these systems;" and from a lodging company expert "This is the best."

Experts did not select **end-user (guest room) technologies** in response to this question, another indication that, collectively, they did not perceive the technologies to be among those that offer the greatest benefits in the industry.

Technologies that provide **Digital, two-way communications with utility** also did not appear as study experts confirmed the low rank assigned to these technologies in identified technologies (Question 1).

Technologies capable of identifying detailed levels of peak vs. non-peak consumption and **Technologies that provide scheduled load shedding** had the same MR (3.58) and SD (0.79) for good reason. **Technologies that provide scheduled load shedding** inherit data from **Technologies capable of identifying detailed levels of peak vs. non-peak consumption**. Therefore, the former is dependent on the latter.

Question 7. Which adopted smart grid technologies have negative impacts on the lodging industry?

Study participants identified the following currently adopted smart grid technologies as having negative impacts in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 7: Delphi Third Round Question 7 Results

Rank	Adopted Smart Grid Technologies Negative Impacts	Mean Rating	Standard Deviation
1	Cost to implement Energy information and Energy management systems	3.92	0.79
2	Utility companies may use smart grid technologies as justification to adjust time-of-use rates in a manner that is not optimal for lodging property consumption requirements and patterns	3.50	0.90
3	Creating a false sense of savings that would cause staff to poorly manage their property and create "usage creep"	3.50	1.09
4	Possibly all - the temptation to "greenwash" is common	3.33	1.23
5	Possibly all-if smart grid technology implementation strategy is poorly executed it may result in negative environmental impact	3.25	0.97
6	Equipment failure due to incompatible controls	3.08	0.51

The *cost* of adopting the previously identified most useful and most beneficial technology, **Energy management systems**, was ranked first among negative impacts on the lodging industry. Study experts commented on this aspect of technology adoption in the first and second rounds as they discussed the merits of adopting EMSs in various sizes of properties and in franchised properties. An expert who represented small lodging properties commented, “This is particularly true in small-business, franchised models. Increased up-front expenditures are unrealistic for many hotel owners/operators in the current economic environment."

Study experts "voiced" their perceptions that **Utility companies may use smart grid technologies as justification to adjust time-of-use rates in a manner that is not optimal for lodging property consumption requirements and patterns** as they ranked this potentially negative impact second. This outlook accounts for the low ranking of technologies with **Digital, two-way communications with utility** when experts identified smart grid technologies that they were aware of (Question 1)

Study experts were not just critical of external forces; they also looked inward when responding to this question. Although the SDs indicated there was a relatively wide range of perspectives as they assessed their own shortcomings, experts ranked poor management (**Creating a false sense of savings that would cause staff to poorly manage their property and create "usage creep"**); disingenuous sustainability efforts (**the temptation to "greenwash" is common**); and poor execution (**if smart grid technology implementation strategy is poorly executed it may result in negative environmental impact)**; third, fourth, and fifth of potential negative impacts on the industry.

The lowest SD (0.51) in the Table accompanied **Equipment failure due to incompatible controls** which opened a window in the study house, and provided a first glimpse into IT protocol issues that would appear in subsequent questions.

Question 8. What are the perceived challenges of adopted smart grid technologies in the lodging industry?

Study participants identified the following challenges of currently adopted smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 8: Delphi Third Round Question 8 Results

Rank	Adopted Smart Grid Technologies Challenges	Mean Rating	Standard Deviation
1	Corporate buy-in/justifying costs to get data. Data is only as good as how you react to it	4.17	0.39
2	Creating a plan and implementation strategy	3.92	0.51
3	Assessing benefits vs. expense	3.75	0.75
4	Service contracts/costs of maintaining technology systems	3.58	0.90
5	Integration of technology/lack of homogeneous solutions	3.50	0.80
6	Up-front expenditures are unrealistic for many owners of smaller properties because many new technologies are initially developed for properties with 200 rooms or more	3.25	1.36
7	ROI for properties with less than 200 rooms is undocumented	2.83	1.11

The highest ranked item in this question, **Corporate buy-in/justifying costs to get data. Data is only as good as how you react to it**, was the first item to appear in the study with one of the lowest SDs of 0.39. There is no doubt that the primary challenge of smart grid technology adoption is corporate buy-in, but there was an indication that there may be hope, at least for large properties. A study expert who persuaded the company he represented to provide funding for, or "buy-in" to, the EIS and EMS he successfully designed and manages said, "Getting the funding to implement the EIS and EMS has been slow, but now that management has seen the benefit, it's full speed ahead." The expert who made the comment represented large, non-franchised, lodging properties. However, an expert who represented small (85 rooms or less) hotels commented, "[the difficulty of getting buy-in] is particularly true in small-business, franchised models. Increased up-front expenditures are unrealistic for many hotel owners/operators in the current economic environment;" and an expert who represented a large franchise model company stated,

> Our company is 100% franchised…meaning that each and every one of our domestic hotels is individually owned and operated. Therefore, our ability to mandate or govern the use of Smart Grid Technology (or any energy management solution) is extremely limited.

An industry consultant characteristically provided this middle-ground solution in response:

> Very common comment in the industry. Guidelines and 'Best practices' can help…but effecting change is difficult. The best solution is to overtly praise the sites that show great success…imitation is the sincerest form of flattery, and don't think that hotel B is going to let hotel A outshine them at anything.

The second lowest SD (0.51) in this question corresponded with the second ranked challenge, **Creating a plan and implementation strategy**, further evidence of experts' understanding of the critical role strategic planning and implementation plays in successful smart grid technology adoption.

Costs of *maintaining* various systems appeared for the first time in the study in **Service contracts/costs of maintaining technology systems**, ranked fourth. **Integration of technology/lack of homogeneous solutions** was ranked fifth. It is no coincidence that these two challenges appeared in sequence as the glimpse of IT protocol issues, **Equipment failure due to incompatible controls**, first seen in negative impacts of adopted smart grid technologies (Question 7), was expanded in this question.

There was disagreement about whether or not realistically priced EMSs have been developed, and Return on Investment (ROI) documented, for hotels with less than 200 rooms. In the second round, a study expert representing properties with less than 200 rooms commented, ". . . many new technologies are initially developed for larger properties (200+ rooms) whereas most of our hotels are 85 rooms or fewer and the ROI for that size is undocumented" but an energy technology provider expert indicated in the third round that he "strongly disagreed" with the statement. The differing opinions are reflected in the SDs of 1.36 and 1.11 respectively for **Up-front expenditures are unrealistic for many owners of smaller properties because many new technologies are initially developed for properties with 200 rooms or more** and **ROI for properties with less than 200 rooms is undocumented.** These SDs were significantly higher than other SDs in the table and comparatively higher than study SDs.

Question 9. What are the perceived risks of adopted smart grid technologies in the lodging industry?

Study participants identified the following risks of currently adopted smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 9: Delphi Third Round Question 9 Results

Rank	Adopted Smart Grid Technologies Risks	Mean Rating	Standard Deviation
1	Meter accuracy	3.25	0.87
2	IT security	3.25	1.14

A MR of 3.00 corresponded with "Neither Agree or Disagree" in the Likert scale for this question, so the same MRs of 3.25 of **Meter accuracy** and **IT security** may be an indication that these risks are not perceived as severe. The relatively large SD of 1.14 for **IT security** reflects expert panel diversity as technology providers chose "strongly disagree" for this question while consultant and lodging experts chose "agree" on the scale.

Question 10. What are the perceived tangible benefits of future smart grid technologies in the lodging industry?

Study participants identified the following tangible benefits of future smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 10: Delphi Third Round Question 10 Results

Rank	Future Smart Grid Technology Tangible Benefits	Mean Rating	Standard Deviation
1	Lower emissions	4.33	0.49
2	Lower energy costs	4.33	0.49
3	Less expensive equipment integration	4.17	0.58
4	Faster speeds enabling identification of "critical" areas by which we can make steep reductions.	4.08	0.51
5	Lower installation costs	4.08	0.51
6	Lower equipment costs	4.08	0.67
7	Company benchmarking	4.00	0.60
8	Introducing guests to energy savings concepts	4.00	0.60
9	Industry benchmarking	3.92	0.67
10	Utility rebates/subsidies	3.92	0.67
11	Property benchmarking	3.75	0.62
12	Some hotels will be able to move off utility pricing to deregulated tariffs where the pricing is significantly lower	3.67	0.89
13	New technologies will help satisfy government mandates and avoid potential fines	3.58	0.79
14	Minimal disruption to guest comfort as a result of IP addressable appliances (HVAC equipment, refrigerators)	3.50	1.00

Fourteen benefits were identified in this question. The only question that produced more items was Question 2 (Methods by which study experts became aware of smart grid technologies). More than any other question in the study, the identification of so many tangible benefits of future smart grid technologies illustrates the optimism study experts have about future smart grid technology adoption. The ranking of **Introducing guests to energy savings concepts** (eighth) above **Industry benchmarking** (ninth), **Utility rebates/subsidies** (tenth) and **property benchmarking** (eleventh), demonstrates this optimism and indicates confidence in the capabilities of future smart grid technologies to provide actionable, real-time, data for guests.

The matching MRs of 4.33 and SDs of 0.49 of **Lower emissions** and **Lower energy costs** is a strong statement of what experts anticipate will impact their bottom lines in the future. Instead of citing various ways of lowering energy costs - better load, time-of-use and DR management; incentives offered by utilities; and reduced payback periods – experts indicated that they expect carbon legislation with negative incentives attached. Another tangible benefit, not identified for currently adopted smart grid technologies, **New technologies will help satisfy government mandates and avoid potential fines,** appeared as experts considered anticipated legislative impacts.

Unlike tangible benefit items for currently adopted smart grid technologies, a focus on equipment was evident for future smart grid technologies. Experts ranked **Less expensive equipment integration**, **Lower installation costs**, and **Lower equipment costs** third, fifth, and sixth respectively. **Utility rebates/subsidies** moved from second for currently adopted smart grid technologies, to tenth for future smart grid technologies, as study experts anticipated greater benefits in lower equipment related costs than in utility incentives as they considered the future. **Cost to implement energy information and energy management systems** was the highest ranked negative impact of currently adopted smart grid technologies. These systems are expensive because they are relatively new technologies. Technology costs decline as technology matures. As smart grid technology costs become less prohibitive, **Utility rebates/subsidies** will steadily become less attractive. Hence, the downward shift of **Utility rebates/subsidies.** As an impassioned study expert considered **Utility rebates/subsidies**, he commented, “Newer/better/cheaper/faster black boxes and technologies will always come available - the key is to let the market eventually accept them sans utility rebates/subsidies. Cramming windmills down our throats hasn't worked, likewise the ethanol subsidies…but CFL's, LED's, and adjustable speed drives have had great market penetration.”

Question 11. What are the perceived intangible benefits of future smart grid technologies in the lodging industry?

Study participants identified the following intangible benefits of future smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 11: Delphi Third Round Question 11 Results

Rank	Future Smart Grid Technologies/Intangible Benefits	Mean Rating	Standard Deviation
1	Incorporation of renewable energy	4.17	0.58
2	Becoming a greener organization	4.17	0.83
3	Ability to quickly identify energy usage abnormalities	4.08	0.51
4	Certain guests (travelers matching particular demographics/psychographics) may appreciate the environmentally friendly aspects of smart grid technology and choose to stay at hotels that use the technologies	4.00	0.43
5	Guest desires for greener operations	4.00	0.43
6	Ability to manage energy consumption from grid with in-house renewable resources	4.00	0.60
7	Positive impact on guests	4.00	0.60
8	Guest expectations for greener operations	4.00	0.85
9	Improved reliability	3.83	0.58
10	Industry goodwill through convergence of information allowing sustainable solutions	3.67	0.89
11	More vibrant employee interests	3.58	1.00
12	Faster outage response	3.42	0.79

Nine intangible benefits of adopted smart grid technologies (Question 5) and twelve intangible benefits of future smart grid technologies were identified. The increased number of intangible benefits for future technologies lies in the presence of items related to renewables and an expanded focus on guests.

Renewable sources were the subject of two intangible benefits, with **Incorporation of renewable energy** ranked first, and **Ability to manage energy consumption from grid with in-house renewable resources**, ranked sixth, a sign of study experts' expectations that renewable generation will be facilitated by smart grid technology adoption. Guests were the subject of four of twelve intangible benefits as **Certain guests (travelers matching particular demographics/psychographics) may appreciate the environmentally friendly aspects of smart grid technology and choose to stay at hotels that use the technologies**; **Guest desires for greener operations**; **Positive impact on guests**; and **Guest expectations for greener operations** ranked fourth, fifth, seventh, and eighth respectively. Although these items have the potential to produce tangible benefits, experts chose to place them in intangible benefits, demonstrating cautious optimism. Evidence of this caution appeared in experts' comments. For example, in response to **Certain guests (travelers matching particular demographics/psychographics) may appreciate the environmentally friendly aspects of smart grid technology and choose to stay at hotels that use the technologies** an expert responded, "This is certainly good, if it is true."

Improved reliability and **Faster outage response** go hand-in-hand because outage response time is a factor used to calculate system reliability. Ranked ninth and twelfth respectively, rankings for these items indicate that lodging industry experts expect these intangible benefits to emerge with smart grid technology adoption, but they do not perceive them as the most important benefits. These priorities are in line with Kwortnik's (2005) findings and they demonstrate the relatively low importance study experts continue to attach to **Improved reliability** and **Faster outage response** despite declining grid reliability.

The affect of smart grid technology adoption on employees appeared in intangible benefits of adopted technologies in **Better comfort conditions for employees**, ranked last in Question 5, and in this question in **More vibrant employee interests**, ranked eleventh of twelve, after items relating to renewables, energy management, utility service, guests, and public relations. The lodging industry is a service industry. Given the profound impact lodging industry employees have on industry success, the low ranks of employee related items is unsettling. When a study expert who represented a company renowned for exceptional hospitality and employee engagement encountered **More vibrant employee interests** as an intangible benefit of future smart grid technology adoption, he responded, “If the energy data is presented to employees.”

Question 12. Which future smart grid technologies do industry experts anticipate may have the greatest benefits?

Study participants anticipate the following future smart grid technologies may have the greatest benefits in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 12: Delphi Third Round Question 12 Results

Rank	Future Smart Grid Technologies Greatest Benefits	Mean Rating	Standard Deviation
1	Technologies with wireless connectivity	3.92	0.90
2	Peak load management technologies	3.83	0.58
3	"Net metering" that enables the sale of renewable energy back onto the grid	3.75	0.62
4	Technologies that facilitate a larger portfolio share of renewable energy generation	3.75	0.62
5	Technologies that enable reduction of high energy loads of siloed amenities	3.58	0.51
6	Mobile applications such as smart phone shut down device controls for appliances	3.42	1.24

Study experts were enamored with wireless connectivity as reflected in the top ranked item, **Technologies with wireless connectivity**. Comments such as "Wireless is always good" and "Wireless connectivity (in any application) is of great benefit to older hotels that cannot afford proper retrofit wiring, and other infrastructure." appeared in the second round as experts anticipated greatly expanded wireless capability of smart grid technologies.

Technologies identified as having the greatest benefits in adopted technologies (Question 6) and in this question were related to peak load in **Technologies capable of identifying detailed levels of peak vs. non-peak consumption**, ranked third of four in Question 6, and **Peak load management technologies**, ranked second, in this question; and load shedding in **Technologies**

that provide scheduled load shedding, ranked fourth of four in Question 6, and **Technologies that enable reduction of high energy loads of siloed amenities**, ranked fifth of six, in this question.

Technologies that were identified as having the greatest benefits for future technology adoption, but were not identified for adopted technology adoption, were focused on renewables and mobile applications. Renewables were represented in **"Net Metering" that enables the sale of renewable energy back onto the grid**, ranked third of six, and **Technologies that facilitate a larger portfolio share of renewable energy generation**, ranked fourth of six. Mobile applications appeared in **Mobile applications such as smart phone shut down device controls for appliances**, ranked sixth of six. The SD (1.24) of **Mobile applications such as smart phone shut down device controls for appliances** was high compared to SDs of other items in this question and in the study as the experts voiced some uncertainty about the technology with comments like "cutting edge here. . ." After reading

> The pending introduction of IP addressable appliances (HVAC equipment, refrigerators, etc. will greatly facilitate the connectivity of these devices to the smart grid. The more devices that can connect the greater reductions in kWh consumption can be achieved with minimal disruption to guest comfort

a study expert responded, "This sounds good, but it's an overkill in my mind."

Question 13. Which smart grid technologies do industry experts anticipate may have negative impacts on the lodging industry?

Study participants anticipate the following future smart grid technologies may have negative impacts in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 13: Delphi Third Round Question 13 Results

Rank	Future Smart Grid Technologies Negative Impacts	Mean Rating	Standard Deviation
1	Proprietary software/hardware, not having open protocols	3.33	1.07
2	Significant use of demand reduction, load shedding, or time-factor charging related technologies runs counter to guest expectations, reduces guest satisfaction and diminishes competitive positioning.	3.17	1.11

The issue of IT Protocols, first glimpsed in adopted smart grid technologies that have negative impacts in the industry (Question 7) in **Equipment failure due to incompatible controls**; and seen in challenges of adopted smart grid technologies (Question 8) in **Integration of technology/lack of homogeneous solutions;** surfaced again in **Proprietary software/hardware, not having open protocols.** The relatively large SD of 1.07 is a reflection of expert panel constitution, as expert energy technology providers who sell proprietary systems strongly disagreed that proprietary systems will have negative impacts on the industry, while others associated with non-proprietary wares strongly agreed that proprietary products will have negative impacts on the industry.

The potential for *significant use* of smart grid technologies to reduce guest satisfaction appeared in **Significant use of demand reduction, load**

shedding, or time-factor charging related technologies runs counter to guest expectations, reduces guest satisfaction and diminishes competitive positioning, ranked second. The potential for reduced guest satisfaction was rigorously discussed in the study. Comments made by some study experts reflected perceptions that guest dissatisfaction may not be an inherent, unavoidable, aspect of technology adoption, rather, the failure to adequately assess, plan, execute, and manage the technologies could trigger potential negative impacts on guests. For example, “Demand response, if not executed well, can have negative impacts on our guests;” “Need to get a plan together and implementation strategy... got to first determine what you would do with the data and what benefits it would produce;” “Practical deployment is a cause for concern, and unless an implementation plan is clearly defined, the perceived risks could be high;” and “Need to use the right technology - this would be part of your smart metering plan.” A technology provider contributed a description of a product that facilitates peak demand reduction with “minimal or no guest inconvenience” with

> As a technology provider to the lodging industry, we have a system that enables properties to opt to participate in peak demand reduction by reducing energy usage in the guestrooms without inconveniencing guests. As an example, a hotel receives notification from the utility that for the next 2 hours the hotel needs to reduce its consumption by x. The XXXXX system would first identify all unrented rooms and open the temperature bands by a few more degrees thus ensuring that no energy will be consumed by the HVAC equipment in those rooms. Then it would identify all rented but currently unoccupied rooms and apply the same strategy. Then, if necessary, it could cycle the equipment on/off in rented and occupied rooms thus cutting back on energy consumption with minimal or no guest inconvenience.

Question 14. What perceived challenges of, or barriers to, do industry experts associate with future smart grid technology adoption?

Study participants identified the following challenges of, or barriers to, future smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 14: Delphi Third Round Question 14 Results

Rank	Future Smart Grid Technologies Challenges/Barriers	Mean Rating	Standard Deviation
1	Equipment replacement cycles may preclude immediate smart grid technology adoption	4.17	0.39
2	Sources of capital to deploy large scale enhancements to the entire system.	4.17	0.39
3	Education - the message needs to be at the right level for the audience making the decisions on smart grid technologies	4.17	0.83
4	Regulatory inconsistency. There are no "overall guidelines/rules" between regulated utilities. A technology considered safe and cost effective by one regulatory body could be considered dangerous and/or burdensome by rate payers in another.	4.00	0.43
5	Fast technology advancement. It's expensive to keep up. The solution yesterday is not the solution today	4.00	0.60
6	Outdated legislation at various levels of government	4.00	0.60
7	Perceived higher cost of entry (new major systems and appliances required to benefit from the smart grid technologies)	3.83	0.39
8	U.S. "one size fits all" federal policy vs. facilitating "distributed generation sources" (micro-grids) in specific areas	3.83	0.39
9	Utility industry failure to fix grid infrastructure	3.83	0.72
10	End-user (guest) misunderstanding of new technologies can lead to a diminished guest experience	3.83	0.94
11	Practical deployment	3.75	0.45
12	Lack of homogeneous/scalable solutions adds significant cost to smart grid technology adoption	3.67	0.65
13	Perception of greater central control of energy consumption	3.42	0.67

Seven challenges of adopted smart grid technology were identified by study experts (Question 8). Thirteen challenges of, or barriers to, future smart grid technology were identified.

Challenges common to adopted technologies and future technologies were in three areas; technology costs; planning, implementation and deployment; and lack of homogeneous solutions.

Technology costs appeared in **Corporate buy-in/justifying costs to get data. Data is only as good as how you react to it for adopted technologies**, ranked first, in adopted technologies; **Equipment replacement cycles may preclude immediate smart grid technology adoption** and **Sources of capital to deploy large scale enhancements to the entire system,** ranked first and second respectively in future technologies. All three of these challenges had MRs of 4.17 and SDs of 0.39. Additionally, **Fast technology advancement. It's expensive to keep up. The solution yesterday is not the solution today** and **Perceived higher cost of entry (new major systems and appliances required to benefit from the smart grid technologies)**, ranked fifth and seventh respectively, appeared as experts considered cost implications of future smart grid technology adoption.

Planning, implementation and deployment appeared in **Creating a plan and implementation strategy** and **Assessing benefits vs. expense** ranked second and third respectively in adopted technologies; and in **Practical deployment**, ranked eleventh in future technologies, as study experts shifted their focus from assessing, planning, and defining implementation strategies in the present to deployment of smart grid technologies in the future.

Lack of homogeneous solutions appeared in **Integration of technology/lack of homogeneous solutions**, ranked fifth in adopted technologies; and **Lack of homogeneous/scalable solutions adds significant cost to smart grid technology adoption**, ranked twelfth in future technologies, an indication that study experts anticipate homogenous solutions will be more readily available in the future than they are now.

Education - the message needs to be at the right level for the audience making the decisions on smart grid technologies, ranked third, relates to Question 2, where study experts indicated that they were primarily educating themselves about smart grid technologies rather than receiving information from governmental, regulatory, utility, or energy technology provider entities. There are exceptions; some lodging companies have a large presence in utility company territories. Lodging experts in these locations "have much interaction with local utilities as XXXXX [lodging company] is generally the largest customer in XXXXX [utility service territory]." Nonetheless, this important challenge had the same MR (4.17) as the three cost related challenges, an indication that collectively, experts perceive a need for effective smart grid technology education. A study expert commented, "In some states, there has been a concerted effort by utilities to sell the benefits of smart meters, and the ancillary benefits they provide. The "call-to-change" is not consistent throughout the complex and somewhat complicated utility landscape."

In addition to education, challenges identified for future smart grid technologies that did not appear in adopted technologies were primarily challenges presented by the U.S. regulatory structure and U.S. smart grid policy. **Regulatory inconsistency. There are no "overall guidelines/rules" between regulated utilities. A technology considered safe and cost effective by one regulatory body could be considered dangerous and/or burdensome by rate payers in another**; **Outdated legislation at various levels of government**; **U.S. "one size fits all" federal policy vs. facilitating "distributed generation sources" (micro-grids) in specific areas**; and **Perception of greater central control of energy consumption**; ranked fourth, sixth, eighth, and thirteenth respectively. Study experts also perceived **Utility industry failure to fix grid infrastructure,** (ranked ninth) which some may argue is a symptom of regulatory structure, as a challenge to future smart grid technology adoption. Experts candidly commented on activity in these areas. Here is an example of a study conversation:

Round 1 Question: *What are the challenges of, or barriers to, future smart grid technology adoption?*

> The current electrical grid infrastructure is unable to handle future load, as well as the inclusion of future renewables and moving renewable energy to areas of the country that cannot produce as much renewable energy. The main barrier to expanding and improving the grid will be of a financial nature. A big supplier of these funds is the federal government. Without subsidies and/or rebates, creating a smart grid will become increasingly more difficult. Current austerity measures being discussed in Congress will delay the roll-out of the smart grid, so that may in fact be the greatest barrier.

Round two responses from two peers:

> This sounds like a "the sky is falling" response - so get a "big government" program to fix all. My feeling is that Utilities need to fix their infrastructure to provide reliable service. Customers will install whatever technologies that are justified and cost-effective and result in a total lower operating cost.
>
> Disagree - the grid could be modified to accept "distributed generation sources" in specific areas, thus creating micro-grids that would function as their own (theoretically more efficient) supply/demand markets. This could allow us to get away from the old "Federal government one-size-fits-all" approach to funding "concepts"…see ethanol and "renewable energy" as examples.

Question 15. What perceived risks do industry experts associate with future smart grid technology adoption?

Study participants identified the following risks of future smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

Table 15: Delphi Third Round Question 15 Results

Rank	Future Smart Grid Technologies Risks	Mean Rating	Standard Deviation
1	Early results may not align with expected savings which may inhibit future investments	3.75	0.62
2	Reliability	3.67	0.65
3	Data Security	3.58	1.00
4	Cyber security	3.42	0.90

Costs appeared again, as the concept of financial risk associated with future smart grid technology adoption was ranked first by study experts in **Early results may not align with expected savings which may inhibit future investments.**

Reliability, ranked second, refers to reliability of smart grid technologies, not grid reliability. The appearance of this risk is not surprising because rapid technology development, and the inevitable race to get new technologies on the market, can result in less than perfect systems. Again, as in Question 9, security was identified by experts in **Data Security** and **Cyber security.** Privacy, surprisingly, was not identified by study participants in response to this question. It may be premature to identify this risk because personally identifiable energy consumption information is not yet being collected with adopted smart grid technologies in the lodging industry. Other plausible explanations for the absence of privacy identification in this question are that study experts' perceptions of

Data security may include privacy; or experts may simply be unaware of potential privacy risks because it resides in the domains of legal and marketing experts who were not represented in the study.

Question 16. Which smart grid technologies do industry experts anticipate will be adopted by the end of year 2015?

Study participants anticipate the following smart grid technologies will be adopted in the U.S. lodging industry by the end of year 2015.

Please indicate how likely you believe it is that each technology will be adopted in the U.S. lodging industry by the end of year 2015.

Table 16: Delphi Third Round Question 16 Results

Rank	Future Smart Grid Technologies Anticipated to be Adopted by the end of 2015	Mean Rating	Standard Deviation
1	"Net Metering" (dependent on the availability and usage of renewable energy sources)	3.67	0.98
2	Demand response controls	3.67	1.07
3	Open protocol monitoring	3.50	0.90
4	Building automation systems that manage on a second-by-second basis (e.g. a hotel receives a request from the utility to reduce consumption by X for the next 2 hours. The system will first identify unrented rooms, open the energy bands, thus ensuring no energy will be consumed by the HVAC in those rooms. Then it will identify rented but unoccupied rooms and apply the same strategy)	3.08	1.16
5	Smart meter deployment to every customer	2.42	1.31

Study experts demonstrated in this question that they anticipate currently available technologies to be improved, and more widely adopted, in the industry by the end of 2015. The top ranking of **"Net Metering" (dependent on the availability and usage of renewable energy sources)** confirmed that experts are looking forward to **Incorporation of Renewable Energy,** ranked first in intangible benefits of future smart grid technologies (Question 11). They also appear to be hopeful that **Open protocol monitoring**, ranked third in this Table, will ameliorate the effects of **Proprietary software/hardware, not having open**

protocols, ranked first among negative impacts of future smart grid technology adoption (Question 13) by 2015. **Smart meter deployment to every customer** had the lowest technology adoption MR in the study (some Awareness Methods had lower MRs) and a SD that reflected experts differing opinions about the likelihood of smart meter deployment. For example, **Smart meter deployment to every customer** by 2020 was anticipated by one study expert, but another expert responded, “only if needed” and a third expert commented,

> As with many things in this country, I think that regional interests and politics play a large role in the future adoption of smart grid technologies. Therefore, as mentioned in this comment, the adoption of smart meters cannot happen consistently across the board, however frustrating that will be.

Question 17. Which smart grid technologies do industry experts anticipate will be adopted by the end of year 2020?

Study participants anticipate the following smart grid technologies will be adopted in the U.S. lodging industry by the end of year 2020.

Please indicate how likely you believe it is that each technology will be adopted in the U.S. lodging industry by the end of year 2020.

Table 17: Delphi Third Round Question 17 Results

Rank	Future Smart Grid Technologies Anticipated to be Adopted by the end of 2020	Mean Rating	Standard Deviation
1	"Smarter" building automation systems, with real-time metering, capable of monitoring grid conditions and/or market conditions, tied to localized distributed generation that can be pre-dispatched at pre-determined points (i.e. if the hourly price of electricity is greater than $xxx.xx/mWh, then dispatch a fuel cell and disconnect from the grid)	3.92	0.79
2	Appliance demand response	3.50	1.09
3	Automotive demand response	3.33	1.15
4	Improved demand response controls (controlling down to specific loads, rather than "banks" of loads)	3.25	1.36
5	Technologies capable of providing communication with generation plants all around the continent.	3.25	1.42

Study experts anticipate expanded capabilities of existing smart grid technologies in **"Smarter" building automation systems, with real-time metering, capable of monitoring grid conditions and/or market conditions, tied to localized distributed generation that can be pre-dispatched at pre-determined points (i.e. if the hourly price of electricity is greater than $xxx.xx/mWh, then dispatch a fuel cell and disconnect from the grid)**; **Improved demand response controls (controlling down to specific loads, rather than "banks" of loads)** and **Technologies capable of providing**

communication with generation plants all around the continent; ranked first, fourth, and fifth respectively.

Unlike smart grid technologies expected to be available by the end of 2015 (Question 16), technologies that are not currently available to the industry, **Appliance demand response** and **Automotive demand response,** ranked second and third respectively, appeared in technologies anticipated to be adopted in the industry by the end of 2020.

4.3 Expert Insights

When I think of the 'smart grid', I typically consider it to only consist of the data exchange between consumer and provider. With that being said, is EMS considered a 'smart grid' technology, or is it just a 'smart energy technology'? Either way, I believe that EMS is making a substantive effect on the U.S. lodging industry, and teamed with smart meters/net metering, will greatly benefit lodging providers going forward to better reduce consumption.

Smart grid technologies like the ones mentioned here are great. They should be embraced and built out…however, don't forget that the lodging industry is generally concerned with one thing - Revenue Per Available Room.

Through "best practices" and automated controls (EMS, Guest room energy management systems) and continual vigilance, hotels can reduce their overall utility/water spend by 20 - 30%.

The temptation to "greenwash" is all too common in this industry…example: buying Renewable Energy Credits (RECs) to appear more eco-friendly. RECs are not in themselves bad, but they shouldn't be a part of a "sustainability strategy" UNTIL the site is absolutely running as "lean as possible". Greenwashing is a lazy shortcut that helps nobody…except the brokers and traders of the certificates.

There is a risk that electrical grid infrastructure will not be able to evolve as quickly as the technology, wasting a precious opportunity to take advantage of this technology to reduce our dependence on fossil fuels.

Hotels should always keep guest satisfaction as the primary goal. If energy can be reduced without impacting guest satisfaction that is when it should be done.

I think the thing that is apparent when dealing with Hotels & Guests . . we want to make sure the Guests are comfortable (so they will have a good experience and decide to return)… but we also want to reduce utility costs – it's a balancing act for sure…

I think that the lodging industry can play a large role in advocating for smart grid technologies nationwide in the future by proving current success in other parts of the country."

Chapter 5

CONCLUSIONS

5.1 Implications

The primary driver of successful smart grid technology adoption on the global stage is the recognition of the necessity of energy efficiency, implemented by governments that possess the power to override individual inclinations and fund technological innovations in accordance with central policies. The social context in which this driver resides does not exist in the U.S. Technology adoption in the U.S. exists in a social context that is manifested in complex governmental framework and a regulatory structure that inhibits efficient technology adoption and discourages collaboration. Nonetheless, collaboration is the most effective way forward for the U.S. lodging industry.

An industry consortium, consisting of energy management experts, should forge and strengthen industry relationships with governmental agencies such as the DOE, the EPA and the NIST, in an effort to influence future codes and standards and keep abreast of stimulus fund availability. The consortium should also monitor and report on federal policy as it relates to the industry. This is clearly of concern to lodging industry experts, as they perceived **U.S. "one size fits all" federal policy vs. facilitating "distributed generation sources" (micro-grids)** and the **Perception of greater central control of energy consumption** as challenges of, or barriers to, smart grid technology adoption.

The three functional differences between the existing national electrical grid and the smart grid are energy flow, data flow and fuel mix. 'Smart' energy flow and fuel mix are dependent on 'smart' data flow. That is, the breakthroughs of 'smart' energy flow and enhanced fuel mix, in the forms of energy exchanges with the grid; and increased renewable generation; cannot materialize without the two-way communications of 'smart' data flow. Study experts demonstrated strong support for energy flow and fuel mix as they awarded high rankings to anticipated future smart grid technologies that facilitate managing energy consumption from the grid with in-house renewable resources and the sale of renewable energy back onto the grid. However, 'smart' data flow, referred to by study experts as **Digital, two-way communications with utility**, was not supported as study experts ranked this smart grid technology the least useful of currently adopted smart grid technologies. Moreover, experts cited **Utility companies may use smart grid technologies as justification to adjust time-of-use rates in a manner that is not optimal for lodging property consumption requirements and patterns** as a negative impact of adopted smart grid technologies. Study results indicate that the issues of two-way data flow with utility companies and regulatory activity that governs time-of-use rate justification must be resolved in order for the advantages and profit potential of SGT adoption to be realized. Therefore, it is imperative that the consortium forge and strengthen industry relationships with utilities and regulatory bodies with the aim of resolving this important issue.

Smart grid technology experts cited education as one of the top-ranked challenges of future smart grid technology adoption; specifically, education at the decision-making level in corporations where smart grid technology adoption decisions will be made. An industry consortium could provide a much-needed smart grid technology educational avenue for internal and external collaborators to explore. A central industry clearinghouse to serve as a repository for smart grid technology adoption information, tailored to the U.S. lodging industry, should be established as part of the educational mission of the consortium.

The cost of implementing smart grid technology is prohibitive. New technology is expensive and capital is hard to obtain. It is difficult for energy management experts to secure corporate buy-in for technology adoption. This hurdle is higher for small hotels, and for companies that are dependent on franchisee technology adoption. Moreover, equipment replacement cycles may preclude timely smart grid technology adoption. Smart grid technology experts perceived incentives, offered by utilities, as a potential source of capital to reduce the financial burden of smart grid technology adoption, as beneficial. To accurately assess the incentive landscape, consortium members should be a heterogeneous group. The group should consist of diverse stakeholders, such as industry energy management consultants, franchisees, franchisers, energy technology providers, entertainment companies, gaming companies, independent hoteliers, and other representative stakeholders. The more perspectives that are brought to the table, the better informed the group will be. This group structure will facilitate an information exchange that will clarify issues like those that surfaced in the research, such as whether or not the ROI for EMSs has been documented for all lodging segments; how best to encourage franchisee energy technology adoption; the implications of proprietary and open protocols; the actual performance of adopted smart grid technologies; and where the capital came from to adopt them. The exchange will also aid stakeholder smart grid technology implementation planning, an issue highly ranked by study experts as a challenge.

Retail electricity incentives have been a recent topic of discussion in smart grid circles, an indication that enhanced incentives may be on the horizon. Incentives from other sources should also be considered. Now is the time for the lodging industry to join forces in order to take advantage of potential sources of capital for smart grid technology adoption. *The U.S. lodging industry must speak with one voice or it will not be heard.*

Experts consistently ranked benefits of guest, or end-user, technologies below benefits of technologies that they control such as DR, EMS, load shedding and "net" metering. They also indicated that they anticipated enhanced benefits of end-user technologies, with capabilities to provide direct energy consumption feedback to guests, in future technologies. It is much more difficult to influence and evaluate guests' environmental awareness and willingness to act on their beliefs than it is to change our own behaviors. An industry cultural commitment to energy efficiency will lead to the proper priorities of self-reliance first and guest-reliance second. This commitment is critical based on experts' assessments of the current usefulness of end-user technologies. Concentrating on altering guests' energy consumption habits is myopic and leaves us missing the larger picture, given that we control a large share of the energy. Having such a focus is analogous to expecting to reduce your electricity bill twenty percent by asking your teenager to spend less time using her laptop and watching the big flat screen TV you installed in her bedroom while you use a manual thermostat to keep the temperature of every room in your home at sixty-five degrees in the summer. Likewise, to expect guests to reduce lodging energy costs because we ask them to, while making the reduction of energy consumption we can control less of a priority, will not achieve the bottom line results the industry will need to survive as energy prices escalate.

The potential for positive change through Corporate Responsibility (CR) efforts focused on advancing guest environmental responsibility is limited. The most economically, ecologically and socially responsible approach is to assume a self-reliant stance, cut energy consumption, reduce carbon emissions, and shift CR resources from attempting to change guest energy consumption behaviors to enhancing employee engagement and improving the communities in which our businesses reside. This approach will provide substantial benefits to the industry and to society.

The future of the U.S. lodging industry will not be determined by the industry's notion of climate change, the probability that guests may pay a premium for "green" property attributes, the relentless pursuit of energy-consuming technological amenities, or guest psychometrics. These issues are small saplings in an enormous forest where energy is naturally generated, efficiently exchanged, and intelligently consumed. Responsible energy management is an imperative; not an alternative. The way forward will be forged by those with a strategic vision in a larger context – the context of smart energy ushered in by evaluation and prudent adoption of smart grid technologies.

5.2 Future Research

This research is an exploratory study in which industry experts generously contributed their perceptions of smart grid technology adoption in the U.S. lodging industry. Many of them had global perspectives and, indeed, represented companies with strong international presences. They limited their contributions for this study to the U.S. even though many of their views were much broader than the geographical scope of this research. There is a need for future research that compares smart grid technology adoption in lodging industries in other countries and regions; an examination of the influence of social contexts of countries leading the smart grid technology race; an examination of the influence of climate on smart grid technology adoption; an examination of the influence of energy prices on smart grid technology adoption; a comparison of smart grid technology adoption in geographic areas with, and without, time-of-use rates in effect; a comparison of smart grid technology adoption in various sizes of hotels; an examination of lodging franchisee perceptions of smart grid technology adoption; a comparison of independent hoteliers and enterprise hoteliers, both domestic and international, of smart grid technology adoption; and follow-up studies in 2015 and 2020 to gauge the accuracy of forecasted smart grid technology adoption in the U.S. lodging industry.

REFERENCES

Albornoz Mulligan, J. (2008). *Data privacy versus data security.* Retrieved October 25, 2010, from http://www.forrester.com/rb/Research/data_privacy_versus_data_security/q/id/43846/t/2

Ali, Y., Mustafa, M., Al-Mashaqbah, S., Mashal, K., & Mohsen, M. (2008). Potential of energy savings in the hotel sector in Jordan. *Energy Conversion and Management, 49*(11), 3391-3397. doi:DOI: 10.1016/j.enconman.2007.09.036

Allen, P. J. (2006). How Disney saves energy (hint: It's not magic). *STRATEGIC PLANNING FOR ENERGY AND THE ENVIRONMENT, 26*, 32-45.

Allen, P. (2005). *How Disney saves energy and operating costs; Disney's energy-management program is founded on energy star, metered data, information technology, and teamwork* Retrieved from http://find.galegroup.com/gtx/infomark.do?&contentSet=IAC-Documents&type=retrieve&tabID=T003&prodId=AONE&docId=A128446929&source=gale&srcprod=AONE&userGroupName=udel_main&version=1.0

American Hotel & Lodging Association. *American Hotel & Lodging Association Green Task Force.* Retrieved April 5, 2011, from http://www.ahla.com/uploadedFiles/AHLA/Programs_and_Initiatives/Green/Green%20Task%20Force%20roster.pdf

Baek, N. C., Shin, U. C., & Yoon, J. H. (2005). A study on the design and analysis of a heat pump heating system using wastewater as a heat source. *Solar Energy, 78*(3), 427-440. doi:DOI: 10.1016/j.solener.2004.07.009

Beccali, M., La Gennusa, M., Lo Coco, L., & Rizzo, G. (2009). An empirical approach for ranking environmental and energy saving measures in the hotel sector. *Renewable Energy, 34*(1), 82-90. doi:DOI: 10.1016/j.renene.2008.04.029

Bechrakis, D. A., McKeogh, E. J., & Gallagher, P. D. (2006). Simulation and operational assessment for a small autonomous wind–hydrogen energy system. *Energy Conversion and Management, 47*(1), 46-59. doi:DOI: 10.1016/j.enconman.2005.03.014

Bergstein, J., Polansky, L., Potent, J. & Ramos, C. (2008). *A quantitative assessment of the environmental resource impacts of the hospitality sector (lodging facilities) in US EPA region 2 2008 EPA NNEMS fellowship paper.* Retrieved September 14, 2010, from http://www.epa.gov/region02/p2/hospitality/documents/Hospitality%20Resource%20Impacts.pdf

Berst, J. (2010). *Why Europe has a higher smart grid IQ than America.* Retrieved December 08, 2010, from http://www.smartgridnews.com/artman/publish/Business_Strategy_News/Why-Europe-has-a-higher-smart-grid-IQ-than-America-3303.html

Best, R. J. (1974). An experiment in Delphi estimation in marketing decision making. *Journal of Marketing Research, 11*(4), pp. 448-452. Retrieved from http://www.jstor.org/stable/3151295

Bohdanowicz, P. (2006). Environmental awareness and initiatives in the Swedish and Polish hotel industries—survey results. *International Journal of Hospitality Management, 25*(4), 662-682. doi:DOI: 10.1016/j.ijhm.2005.06.006

Bohdanowicz, P., & Martinac, I. (2007). Determinants and benchmarking of resource consumption in hotels—Case study of Hilton international and Scandic in Europe. *Energy and Buildings, 39*(1), 82-95. doi:DOI: 10.1016/j.enbuild.2006.05.005

Brancheau, J. C., Janz, B. D., & Wetherbe, J. C. (1996). *Key issues in information systems management: 1994-95 SIM Delphi results* Retrieved from http://find.galegroup.com/gtx/infomark.do?&contentSet=IAC-Documents&type=retrieve&tabID=T002&prodId=AONE&docId=A18757048&source=gale&srcprod=AONE&userGroupName=udel_main&version=1.0

Brockhoff, K. (1975). The performance of forecasting groups in computer dialogue and face-to-face discussion. In H. A. Linstone, & M. Turloff (Eds.), *The Delphi method: Techniques and applications* (pp. 291-321) Addison-Wesley.

Butler, J. (2008). The compelling “Hard case” for “Green” hotel development. *Cornell Hospitality Quarterly, 49*(3), 234-244.

Chan, E. S. W. (2008). Barriers to EMS in the hotel industry. *International Journal of Hospitality Management, 27*(2), 187-196. doi:DOI: 10.1016/j.ijhm.2007.07.011

Chan, E. S. W., & Wong, S. C. K. (2006). Motivations for ISO 14001 in the hotel industry. *Tourism Management, 27*(3), 481-492. doi:DOI: 10.1016/j.tourman.2004.10.007

Chan, W. W. (2005). Predicting and saving the consumption of electricity in sub-tropical hotels. *International Journal of Contemporary Hospitality Management, 17*(3), 228-237.

Chan, W. W. (2009). Environmental measures for hotels' environmental management systems: ISO 14001. *International Journal of Contemporary Hospitality Management, 21*(5), 542-560.

Chan, W. W., & Ho, K. (2006). Hotels' environmental management systems (ISO 14001): Creative financing strategy. *International Journal of Contemporary Hospitality Management, 18*(4), 302-316.

Chao-zhen, L., Jian-ming, G., & Xing-hua, H. (2008). Influence of energy demands ratio on the optimal facility scheme and feasibility of BCHP system. *Energy and Buildings, 40*(10), 1876-1882. doi:DOI: 10.1016/j.enbuild.2008.04.004

Colorado Department of Regulatory Agencies Public Utilities Commission. (2011). *Colorado department of regulatory agencies public utilities commission, PSCO application for SmartGridCity CPCN.* Retrieved April 17, 2011, from https://www.dora.state.co.us/pls/efi/EFI.Show_Docket?p_session_id=&p_docket_id=10A-124E

Cornell University. (2010). *Cornell university school of hotel administration, the center for hospitality research, sustainability roundtable.* Retrieved December 11, 2010, from http://www.hotelschool.cornell.edu/research/chr/events/roundtables/sustainability.html

Custer, R., Scarcella, J., & Stewart, B. (1999). The modified Delphi technique - A rotational modification. *Journal of Vocational and Technical Education, 15*(2) Retrieved from http://scholar.lib.vt.edu/ejournals/JVTE/v15n2/custer.html

Dalkey, N. C., & Helmer, O. (1963). An experimental application of the Delphi method to the user of experts. *Management Science, 9*(3), 458 - 67.

Dalton, G. J., Lockington, D. A., & Baldock, T. E. (2008). Feasibility analysis of stand-alone renewable energy supply options for a large hotel. *Renewable Energy, 33*(7), 1475-1490. doi:DOI: 10.1016/j.renene.2007.09.014

Dalton, G. J., Lockington, D. A., & Baldock, T. E. (2009). Case study feasibility analysis of renewable energy supply options for small to medium-sized tourist accommodations. *Renewable Energy, 34*(4), 1134-1144. doi:DOI: 10.1016/j.renene.2008.06.018

Dalton, G. J., Lockington, D. A., & Baldock, T. E. (2009). Feasibility analysis of renewable energy supply options for a grid-connected large hotel. *Renewable Energy, 34*(4), 955-964. doi:DOI: 10.1016/j.renene.2008.08.012

Desideri, U., Proietti, S., & Sdringola, P. (2009). Solar-powered cooling systems: Technical and economic analysis on industrial refrigeration and air-conditioning applications. *Applied Energy, 86*(9), 1376-1386. doi:DOI: 10.1016/j.apenergy.2009.01.011

Electric Power Research Institute. (2010). *Methodological approach for estimating the benefits and costs of smart grid demonstration projects.* Retrieved September 25, 2010, from http://www.smartgridnews.com/artman/uploads/1/1020342EstimateBCSmartGridDemo2010_1_.pdf

Energy Star, US Environmental Protection Agency, US Department of Energy. (2007). *Energy star building upgrade manual, chapter 12, "facility type: Hotels and motels".* Retrieved October 26, 2010, from http://www.energystar.gov/ia/business/EPA_BUM_CH12_HotelsMotels.pdf

Erdogan, N., & Baris, E. (2007). Environmental protection programs and conservation practices of hotels in Ankara, turkey. *Tourism Management, 28*(2), 604-614. doi:DOI: 10.1016/j.tourman.2006.07.003

Faucher, J., Everett, A. M. & Lawson, R.*APPLYING A MODIFIED DELPHI APPROACH TO DETERMINE THE CURRENT STATE OF THE CONCEPT OF KNOWLEDGE*
. Retrieved December 1, 2010, from http://www.decisionsciences.org/Proceedings/DSI2008/docs/480-4598.pdf

Federal Energy Regulatory Commission. (2006). *Final report on the august 14, 2003 blackout in the United States and Canada [electronic version].simplified diagram of AC electricity distribution from generation stations to consumers.* Retrieved June 25, 2010, from http://www.ferc.gov/industries/electric/indus-act/blackout/09-06-final-report.pdf.

Gaglia, A. G., Balaras, C. A., Mirasgedis, S., Georgopoulou, E., Sarafidis, Y., & Lalas, D. P. (2007). Empirical assessment of the Hellenic non-residential building stock, energy consumption, emissions and potential energy savings. *Energy Conversion and Management, 48*(4), 1160-1175. doi:DOI: 10.1016/j.enconman.2006.10.008

Garthwaite, J.*Hacking the car: Cyber security risks hit the road*. Retrieved September 13, 2010, from http://gigaom.com/cleantech/hacking-the-car-cyber-security-risks-hit-the-road/

Hiremath, R. B., Kumar, B., Balachandra, P., Ravindranath, N. H., & Raghunandan, B. N. (2009). Decentralised renewable energy: Scope, relevance and applications in the Indian context. *Energy for Sustainable Development, 13*(1), 4-10. doi:DOI: 10.1016/j.esd.2008.12.001

International Energy Agency.*Key world statistics 2009.* Retrieved December 11, 2010, from http://www.iea.org/textbase/nppdf/free/2009/key_stats_2009.pdf

International Energy Agency. (2010). *About the IEA.* Retrieved December 06, 2010, from http://www.iea.org/about/index.asp

Karagiorgas, M., Tsoutsos, T., Drosou, V., Pouffary, S., Pagano, T., Lara, G. L., & Melim Mendes, J. M. (2006). HOTRES: Renewable energies in the hotels. an extensive technical tool for the hotel industry. *Renewable and Sustainable Energy Reviews, 10*(3), 198-224. doi:DOI: 10.1016/j.rser.2004.09.012

Karagiorgas, M., Tsoutsos, T., & Moiá-Pol, A. (2007). A simulation of the energy consumption monitoring in Mediterranean hotels: Application in Greece. *Energy and Buildings, 39*(4), 416-426. doi:DOI: 10.1016/j.enbuild.2006.07.008

Kaundinya, D. P., Balachandra, P., & Ravindranath, N. H. (2009). Grid-connected versus stand-alone energy systems for decentralized power—A review of literature. *Renewable and Sustainable Energy Reviews, 13*(8), 2041-2050. doi:DOI: 10.1016/j.rser.2009.02.002

Krakhmal, V. (2006). Customer profitability accounting in the context of hotels. In Peter Harris, & Marco Mongiello (Eds.), *Accounting and financial management* (pp. 188-210). Oxford: Butterworth-Heinemann. doi:DOI: 10.1016/B978-0-7506-6729-6.50018-2

Kwortnik, R. (2005). Safeguarding hospitality service when the unexpected happens. *Cornell Hotel and Restaurant Administration Quarterly, 46*(1), 13-39.

Kwortnik, R. J. (2005). Preparing for disaster. *Cornell Hotel and Restaurant Administration Quarterly, 46*(1), 47-51. doi:10.1177/0010880404272016

Li, C. Z., Shi, Y. M., & Huang, X. H. (2008). Sensitivity analysis of energy demands on performance of CCHP system. *Energy Conversion and Management, 49*(12), 3491-3497. doi:DOI: 10.1016/j.enconman.2008.08.006

Mateus, T., & Oliveira, A. C. (2009). Energy and economic analysis of an integrated solar absorption cooling and heating system in different building types and climates. *Applied Energy, 86*(6), 949-957. doi:DOI: 10.1016/j.apenergy.2008.09.005

Mensah, I. (2006). Environmental management practices among hotels in the greater Accra region. *International Journal of Hospitality Management, 25*(3), 414-431. doi:DOI: 10.1016/j.ijhm.2005.02.003

Miller, J. (2011). *The smart grid's missing ingredient: Performance feedback.* Retrieved April 28, 2011, from http://www.smartgridnews.com/artman/publish/Business_Strategy/The-smart-grid-s-missing-ingredient-performance-feedback-3641.html

Murphy M.K., Black N., Lamping D.L., McKee C.M., Sanderson C.F.B., Askham J. et al. (1998). Consensus development methods and their use in clinical guideline development *Health Technology Assesment*

Ndoye, B., & Sarr, M. (2008). Analysis of domestic hot water energy consumption in large buildings under standard conditions in Senegal. *Building and Environment, 43*(7), 1216-1224. doi:DOI: 10.1016/j.buildenv.2007.02.012

New Paradigm Resources Group. (2001). *Bandwidth trading.* Retrieved December 12, 2010, from http://www.mindbranch.com/Bandwidth-Trading-R257-042/

North Carolina State University. *Database of state incentives for renewables and efficiency (DSIRE).* Retrieved October 25, 2010, from http://www.dsireusa.org/

Oh, S., Oh, H., & Kwak, H. (2007). Economic evaluation for adoption of cogeneration system. *Applied Energy, 84*(3), 266-278. doi:DOI: 10.1016/j.apenergy.2006.08.002

Önüt, S., & Soner, S. (2006). Energy efficiency assessment for the Antalya region hotels in Turkey. *Energy and Buildings, 38*(8), 964-971. doi:DOI: 10.1016/j.enbuild.2005.11.006

Ostrom, A., Bitner, M., Brown, S., Burkhard, K., Goul, M., Smith-Daniels, V., . . . Rabinovich, E. (2010). Moving forward and making a difference: Research priorities for the science of service. *Journal of Service Research, 13*(1), 4-36.

Pacific Gas and Electric. (2007). *Demand response: Hospitality.* Retrieved December 11, 2010, from http://pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/demandresponse/incentives/Hospitality_DR_CaseStudy.pdf

Pavlatos, O., & Paggios, I. (2009). Activity-based costing in the hospitality industry: Evidence from Greece. *Journal of Hospitality & Tourism Research, 33*(4), 511-527.

Pelet, X., Favrat, D., & Leyland, G. (2005). Multiobjective optimisation of integrated energy systems for remote communities considering economics and CO2 emissions. *International Journal of Thermal Sciences, 44*(12), 1180-1189. doi:DOI: 10.1016/j.ijthermalsci.2005.09.006

Penny, W. Y. K. (2007). The use of environmental management as a facilities management tool in the Macao hotel sector. *Facilities, 25*(7-8), 286-295.

Piacentino, A., & Cardona, F. (2008). An original multi-objective criterion for the design of small-scale polygeneration systems based on realistic operating conditions. *Applied Thermal Engineering, 28*(17-18), 2391-2404. doi:DOI: 10.1016/j.applthermaleng.2008.01.017

Pivo, G. (2009). Social and environmental metrics for US real estate portfolios: Sources of data and aggregation methods. *Journal of Property Investment & Finance, 27*(5), 481-510.

Powell, C. (2003). The Delphi technique: Myths and realities. *Journal of Advanced Nursing, 41*(4), 376-382. doi:10.1046/j.1365-2648.2003.02537.x

Priyadarsini, R., Xuchao, W., & Eang, L. S. (2009). A study on energy performance of hotel buildings in Singapore. *Energy and Buildings, 41*(12), 1319-1324. doi:DOI: 10.1016/j.enbuild.2009.07.028

Rosselló-Batle, B., Moià, A., Cladera, A., & Martínez, V. (2010). Energy use, CO2 emissions and waste throughout the life cycle of a sample of hotels in the Balearic islands. *Energy and Buildings, 42*(4), 547-558. doi:DOI: 10.1016/j.enbuild.2009.10.024

Rowe, E. (1994). Enhancing judgement and decision making: A critical and empirical investigation of the delphi technique. Unpublished Ph.D. Thesis

Rowe, G., & Wright, G. (1999). The Delphi technique as a forecasting tool: Issues and analysis. *International Journal of Forecasting, 15*(4), 353-375. doi:DOI: 10.1016/S0169-2070(99)00018-7

Rubio-Maya, C., Uche-Marcuello, J., Martínez-Gracia, A., & Bayod-Rújula, A. A. (2010). Design optimization of a polygeneration plant fuelled by natural gas and renewable energy sources. *Applied Energy,* doi:DOI: 10.1016/j.apenergy.2010.07.009

Ruiz-Molina, M., Gil-Saura, I., & Moliner-Velázquez, B. (2010). Good environmental practices for hospitality and tourism: The role of information and communication technologies. *Management of Environmental Quality: An International Journal, 21*(4), 464-476.

SBI Energy. (2009). *Smart grid technologies, markets, components and trends worldwide.* Retrieved October 27, SB1926639, from http://www.sbireports.com/Smart-Grid-Technologies-1926639/

Scanlon, N. L. (2007). An analysis and assessment of environmental operating practices in hotel and resort properties. *International Journal of Hospitality Management, 26*(3), 711-723. doi:DOI: 10.1016/j.ijhm.2006.07.003

Scott, J. (2003). *THE BLACKOUT OF 2003: THE STRANDED; in subways, in traffic in elevators: All stuck.* Retrieved December 11, 2010, from http://www.nytimes.com/2003/08/15/nyregion/the-blackout-of-2003-the-stranded-in-subways-in-traffic-in-elevators-all-stuck.html

Silverstein, K. (2010). *Utilities regulation: The European experience.* Retrieved December 07, 2010, from http://www.commodities-now.com/news/power-and-energy/2682-utilities-regulation-the-european-experience.html

SMARTGRIDNEWS.COM. (2011). Retrieved August 24, 2010, from http://www.smartgridnews.com/

Southern Colorado transmission improvements: A certificate of public convenience and necessity. (2011). Retrieved April 1, 2011, from http://www.socotransmission.com/Purpose/convenience.cfm

Spinelli, T. (1983). The Delphi decision-making process. *Journal of Psychology, 113*(1), 73. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=5187995&site=ehost-live

State Grid Corporation of China. (2010). ***First smart community demonstration project by north china power grid company completed***. Retrieved December 11, 2010, from http://www.sgcc.com.cn/ywlm/gsyw-e/234180.shtml

Taylor, S., Peacock, A., Banfill, P., & Shao, L. (2010). Reduction of greenhouse gas emissions from UK hotels in 2030. *Building and Environment, 45*(6), 1389-1400. doi:DOI: 10.1016/j.buildenv.2009.12.001

Timothy, D. J., & Teye, V. B. (2009). Accommodations and the green movement. In *Tourism and the lodging sector* (pp. 81-99). Oxford: Butterworth-Heinemann. doi:DOI: 10.1016/B978-0-7506-8659-4.00006-9

Twenty-First Strategies, L. (December 11, 2009). *Power partners resource guide, smart grid technology.* Retrieved September 25, 2010, from http://uspowerpartners.org/Topics/SECTION4Topic-SmartGrid.htm

Underhill, N. (2004). *The Delphi technique.* Retrieved September 25, 2010, from http://www.britishcouncil.org/eltons-delphi_technique.pdf

United States of America Central Intelligence Agency. (2010). *The world factbook: European union.* Retrieved December 10, 2010, from https://www.cia.gov/library/publications/the-world-factbook/geos/ee.html#

United States of America Department of Commerce, National Institute of Standards and Technology. (2010). *NISTIR 7628 Guidelines for Smart Grid Cyber Security: Vol. 3, Supportive Analyses and References*. Retrieved November 2, 2010 from http://csrc.nist.gov/publications/nistir/ir7628/nistir-7628_vol3.pdf

United States of America Department of Energy, Litos Strategic Communication. (2008). *THE SMART GRID: AN INTRODUCTION.* Retrieved December 6, October 25, 2010, from http://www.oe.energy.gov/DocumentsandMedia/DOE_SG_Book_Single_Pages(1).pdf

United States of America Department of Energy, Litos Strategic Communication. (2009). *WHAT THE SMART GRID MEANS TO AMERICANS.* Retrieved November 2, 2010, from http://www.oe.energy.gov/DocumentsandMedia/ConsumerAdvocates.pdf

United States of America Energy Information Administration. (2010). *Country analysis briefs.* Retrieved December 12, 2010, from http://www.eia.doe.gov/emeu/cabs/China/pdf.pdf

United States of America Energy Information Administration. (2010). *Short-term energy and winter fuels outlook.* Retrieved October 25, 2010, from http://www.eia.doe.gov/emeu/steo/pub/contents.html

United States of America Energy Information Administration. (2011). *US electric power industry net generation, 2009.* Retrieved April 7, 2011, from http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html

United States of America Environmental Protection Agency. (2008). *EPA's green power partnership renewable energy certificates.* Retrieved December 8, 2010, from http://www.epa.gov/greenpower/documents/gpp_basics-recs.pdf

United States of America Environmental Protection Agency. (2008). *Sector collaborative on energy efficiency accomplishments and next steps A RESOURCE OF THE NATIONAL ACTION PLAN FOR ENERGY EFFICIENCY.* Retrieved September 22, September 14, 2010, from http://www.epa.gov/cleanenergy/documents/suca/sector_collaborative.pdf

United States of America Environmental Protection Agency Combined Heat and Power Partnership. (2010). *Hotels and casinos.* Retrieved September 14, 2010, from http://www.epa.gov/chp/markets/casinos.html

United States of America Environmental Protection Agency National Service Center for Environmental Publications (NSCEP).*Hotels: An overview of energy use and energy efficiency opportunities.* Retrieved September 14, 2010, from http://nepis.epa.gov/Exe/ZyNET.exe/P1004NH9.txt?ZyActionD=ZyDocument&Client=EPA&Index=2006%20Thru%202010&Docs=&Query=430R07027%20or%20hotels%20or%20energy%20or%20consumption&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=pubnumber%5E%22430R07027%22&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=pubnumber&IntQFieldOp=1&ExtQFieldOp=1&XmlQuery=&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C06THRU10%5CTXT%5C00000009%5CP1004NH9.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=10&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1

United States Green Building Council. (2010). *HOSPITALITY.* Retrieved October 26, 2010, from http://www.usgbc.org/DisplayPage.aspx?CMSPageID=2119

United States Green Building Council. (2010). *LEED and the hospitality industry.* Retrieved October 26, 2010, from http://www.usgbc.org/ShowFile.aspx?DocumentID=5301

Wang, J., Zhai, Z. (., Jing, Y., & Zhang, C. (2010). Optimization design of BCHP system to maximize to save energy and reduce environmental impact. *Energy, 35*(8), 3388-3398. doi:DOI: 10.1016/j.energy.2010.04.029

Woetzel, J. R. (2008). *Reassessing china's state-owned enterprises.* Retrieved December 1, 2010, from http://www.mckinsey.it/storage/first/uploadfile/attach/140418/file/reth08.pdf

Woo, J. (2009). *Solar cell phones go on sale.* Retrieved October 11, 2010, from http://online.wsj.com/article/SB10001424052748703790404574472791840523758.html

World Economic Forum in partnership with Accenture. (2010). *ACCELERATING SUCCESSFUL SMART GRID PILOTS.* Retrieved September 15, 2010, from http://www.smartgridnews.com/artman/uploads/1/WEF_EN_SmartGrids_Pilots_Report_2010_1_.pdf

Xuchao, W., Priyadarsini, R., & Siew Eang, L. (2010). Benchmarking energy use and greenhouse gas emissions in Singapore's hotel industry. *Energy Policy, 38*(8), 4520-4527. doi:DOI: 10.1016/j.enpol.2010.04.006

Xydis, G., Koroneos, C., & Polyzakis, A. (2009). Energy and exergy analysis of the Greek hotel sector: An application. *Energy and Buildings, 41*(4), 402-406. doi:DOI: 10.1016/j.enbuild.2008.11.001

Yoshimura, H. (2006). *The benefits of demand response.* Retrieved December 10, 2010, from http://www.buildings.com/Magazine/ArticleDetails/tabid/3413/ArticleID/3462/Default.aspx

Yu, F. W., & Chan, K. T. (2005). Electricity end-use characteristics of air-cooled chillers in hotels in Hong Kong. *Building and Environment, 40*(1), 143-151. doi:DOI: 10.1016/j.buildenv.2004.05.009

Appendix A

HUMAN SUBJECTS APPROVAL

UNIVERSITY OF DELAWARE

RESEARCH OFFICE

210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE:	January 4, 2011
TO:	Diane Vondrasek
FROM:	University of Delaware IRB
STUDY TITLE:	[208134-1] The Future of Smart Grid Technology in the U.S. Lodging Industry: A Delphi Study
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	January 4, 2011
REVIEW CATEGORY:	Exemption category #2

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will put a copy of this correspondence on file in our office. Please remember to notify us if you make any substantial changes to the project.

If you have any questions, please contact Jody-Lynn Berg at (302) 831-1119 or jlberg@udel.edu. Please include your study title and reference number in all correspondence with this office.

Appendix B

DELPHI STUDY INVITATION

Dear (Industry Expert Name):

I am a graduate student at the University of Delaware, completing my MS in Hospitality Information Management. My professional background is in the energy industry and the focus of my research is energy management. I am conducting a study about the future of smart grid technology in the United States lodging industry for my thesis. The purpose of the study is to provide information to enhance lodging industry energy management efforts by increasing awareness and understanding of the potential benefits and challenges of smart grid technology adoption. You have been identified as an industry expert and selected to participate because of your leadership and innovative approach to energy management.

The Delphi method is being used in the study. The first round consists of 10 or 17 questions, depending on the status of smart grid technology adoption at your company (or client companies). Subsequent rounds take very little time. First round responses will be merged into a single document and sent to participants for comments in the second round. In this way, you will know what other experts have contributed, although their identities will not be disclosed. The final round will be used to rank findings identified in previous rounds.

As the sole investigator, I will maintain the confidentiality of your identity, company affiliation, and contact information. No identifying information will appear in the study. Experts who participate in all rounds will receive an executive summary of the study.

Please indicate whether you will participate in the study, designate a colleague to participate, or decline, by replying to this email by [date varied depending on when invitation was sent]. If you designate a colleague to participate, please include contact information. First round study questions will be emailed upon receipt of participation confirmation. If you have questions about the study, please contact me by email or by phone at xxx.xxx.xxxx

I very much appreciate your time and look forward to hearing from you.

Best regards,

Diane M. Vondrasek
MS Candidate
Hospitality Information Management
Lerner College of Business & Economics
University of Delaware
Raub Hall
14 W. Main St.
Newark, Delaware 19716
USA

Appendix C

DELPHI FIRST ROUND INSTRUMENT

University of Delaware | Alfred Lerner College of Business & Economics
DEPARTMENT OF HOTEL, RESTAURANT & INSTITUTIONAL MANAGEMENT

The Future of Smart Grid Technology in the U.S. Lodging Industry: A Delphi Study

First Round Delphi Questions

1. What smart grid technologies are you aware of that may apply to the U.S. lodging industry?

2. How did the smart grid technologies identified in Question 1 come to your attention?

*If smart grid technologies have been adopted in your lodging property, company, or client company, please answer Questions 3 - 17. If smart grid technologies have **not** been adopted, please skip questions 3 – 9 and answer Questions 10 - 17.*

3. Please identify smart grid technologies that have been adopted in your lodging property, company, or client company.

4. What are the *tangible* benefits of smart grid technologies identified in Question 3?

5. What are the *intangible* benefits of smart grid technologies identified in Question 3?

6. Which smart grid technologies identified in Question 3 have the greatest benefits?

7. Which smart grid technologies identified in Question 3 have negative impacts?

8. What challenges have the smart grid technologies identified in Question 3 presented?

9. What are the risks associated with the smart grid technologies identified in Question 3?

10. What *tangible* benefits of *future* smart grid technology adoption do you anticipate?

11. What *intangible* benefits of *future* smart grid technology adoption do you anticipate?

12. Which smart grid technologies do you anticipate may have the greatest benefits? (Exclude currently adopted smart grid technologies, if any)

13. Which smart grid technologies do you anticipate may have negative impacts? (Exclude currently adopted smart grid technologies, if any)

14. What are the challenges of, or barriers to, *future* smart grid technology adoption?

15. What risks may be associated with *future* smart grid technology adoption?

16. Please identify the smart grid technologies you anticipate will be adopted by the end of the year 2020.

17. Which of the smart grid technologies identified in Question 16 do you anticipate will be adopted by the end of year 2015?

---

18. Please use this area for comments:

THANK YOU!

Appendix D

DELPHI SECOND ROUND LETTER

UNIVERSITY OF DELAWARE | Alfred Lerner College of Business & Economics

DEPARTMENT OF HOTEL, RESTAURANT & INSTITUTIONAL MANAGEMENT

Dear (Industry Expert Name):

You have been so incredibly generous with your time and expertise - I can't thank you enough for participating in my research study! All first round study responses have been submitted and feedback has been overwhelmingly positive.

The second study round is attached. I hope you enjoy reading it as much as I enjoyed putting it together. **The purpose of the second round is to provide each expert with the opportunity to contribute additional ideas, clarifications, and elaborations based on the initial survey responses.** The format is the same as the first round. The areas you have the option to contribute additional ideas, clarifications, and elaborations are indicated in green. A cautionary word - please don't be put off by the length of the document - well over half of it is blank space for comments. Returning the second round document will confirm continued participation.

Please return the second round by **Monday, February 28**. It's important to have ample time to consider the information, so please let me know if February 28 is not realistic for you. A Delphi study is a mechanism used to facilitate a conversation between experts. I will continue to do everything I can to facilitate this conversation.

Your peer experts (a.k.a. smart grid technology study awesome participants) are genuinely interested in the future of smart grid technology in the U.S. lodging industry. Please stay with us. The third, and final, round will be used to simply rank issues identified and clarified in the first and second rounds.

Many thanks for your time and attention. I'm looking forward to receiving your second round comments!

Best regards,

Diane M. Vondrasek
MS Candidate
Hospitality Information Management
Lerner College of Business & Economics
University of Delaware
Raub Hall
14 W. Main St.
Newark, Delaware 19716
USA

Appendix E

DELPHI SECOND ROUND INSTRUMENT

University of Delaware | Alfred Lerner College of Business & Economics
DEPARTMENT OF HOTEL, RESTAURANT & INSTITUTIONAL MANAGEMENT

The Future of Smart Grid Technology in the U.S. Lodging Industry: A Delphi Study

Delphi Second Round

1. **What smart grid technologies are you aware of that may apply to the U.S. lodging industry?**

- Typical smart grid meters, 'net metering', and the Google Power Meter
- Smart meters (near real-time measurement)
- I have used smart meters with several of my clients.
- Smart meters are being installed nationwide, but not in a consistent manner.
- Data Acquisition Servers, smart meters, control systems
- Energy Information Systems including submetering
- Energy Management Systems
- Property management systems
- Demand Response technology
- The technologies that apply to the lodging industry are centered around demand reduction or load shifting.
- Secondarily, there are end-user technologies related to guest room energy management, real-time energy management reporting which can stand alone or be combined with smart-grid connectivity.
- As a technology provider to the lodging industry, we have a system that enables properties to opt to participate in peak demand reduction by reducing energy usage in the guestrooms without inconveniencing guests. We are currently working on the next generation application that would allow this rate of participation to be managed on a second-by-second basis.
- Smart grid technology has been slow to adoption in the lodging industry. The technology is really benefitting the transmission and distribution utility providers, who are now able to manage peak load demand.
- Digital two-way communications with utility
- Enhancements to present electricity grid and performance
- IBM, Siemens [smart grid technology solution providers]

Please place general comment(s) about responses to question 1 here:

1

2. **How did the smart grid technologies identified in Question 1 come to your attention?**

- Articles and Publications
- Individual research and news coverage
- Personal contacts in the industry
- Local utility news, public utility commission filings, experience in data measurement, general news
- Industry articles, on-line search
- Industry experience, trade shows, introductions, joint projects
- When I was with XXXXX Corporation, we used smart meters for various energy studies.
- We implemented these [Energy Information Systems including submetering, Energy Management Systems] many years ago, well before the Industry coined the "smart metering" buzz word.
- In some states, there has been a concerted effort by utilities to sell the benefits of smart meters, and the ancillary benefits they provide. The "call-to-change" is not consistent throughout the complex and somewhat complicated utility landscape.
- Information provided to us by electric utilities and client inquiries instigated our development efforts.
- In approximate order of exposure to the idea: from vendors, then utilities, then in-house staff knowledgebase

Please place general comment(s) about responses to question 2 here:

3. **Please identify smart grid technologies that have been adopted in your lodging property, company, or client company.**

- Development of a custom web-based Energy Information System that provides FEEDBACK to customers on their energy usage. This includes data from monthly billing data and submetering data that provides daily and hourly trends for near-real time information. Also, the installation of an enterprise energy management system that CONTROLS facility HVAC and lighting based on times schedules and temperature setpoints.
- Many of the old electric meters at our CA properties have been replaced by smart meters that accurately measure real time usage of electricity at the hotel. Our large Houston properties have also installed telemetry at on the gas lines which has allowed the hotel to go off utility pricing.

- Remote monitoring through our company development
- Smart meters for energy management, demand response, net-metering, scheduled load-shedding, and daylight harvesting.
- Limited number of electrical meters capable of measuring consumption in 15-min increments with two-way communications with the utility

Please place general comment(s) about responses to question 3 here:

4. What are the *tangible* benefits of smart grid technologies identified in Question 3?

- Lower Energy Consumption and Costs
- Smart meters allow the utilities to gather information that enable/support the organization in managing peak demand load and develop a streamline generation strategy. Load management is critical in the process of balancing the supply of electricity on the electric grid. Poor demand side management results in high costs for utilities which inevitably get passed down to their constituents.
- Utilities are paying hotels for choosing to participate in peak demand reduction (tens of thousands of dollars/year) and are likely to offer enhanced participation fees for more timely response.
- Lower energy bills through proactive management
- Measuring the power consumed for specific areas and activities. This allows the ability to benchmark and track improvement and cost savings.
- Our affected properties have access to detailed consumption information by hour of the day, allowing for more effective time-of-use management and peak demand shaving strategies, resulting in lower overall electricity costs

Please place general comment(s) about responses to question 4 here:

5. What are the *intangible* benefits of smart grid technologies identified in Question 3?

- Better comfort conditions for our Guests and employees
- Energy conservation is clearly an intangible benefit.
- Knowing you can watch progress and track improvement
- Sustainability, public relationships as a green company
- Hotel's opportunity for public relations and advertising its green efforts and thus attract groups and

individual travelers to prefer those types of properties

- Should result in more reliable overall service from the utility due to greater efficiencies in managing the generation and distribution system

Please place general comment(s) about responses to question 5 here:

6. Which smart grid technologies identified in Question 3 have the greatest benefits?

- Properly operating Energy Management System results in lower energy costs.
- Remote monitoring due to lower energy costs
- [Technologies capable of] Identifying the detailed levels of consumption in peak vs. non-peak hours
- [Technologies that provide] Energy management and scheduled load-shedding.

Please place general comment(s) about responses to question 6 here:

7. Which smart grid technologies identified in Question 3 have negative impacts?

- There are really no negative impacts, except the cost to properly implement the Energy Information System and Energy Management System.
- A poorly executed strategy for smart grid technology results in significant costs to the supply chain. The environmental impact is negative and results in increased CO_2 emissions.
- [Technologies] May give the utility justification in adjusting time-of-use rates in a manner that is not optimal for our consumption requirements and patterns

Please place general comment(s) about responses to question 7 here:

8. What challenges have the smart grid technologies identified in Question 3 presented?

- Integration of technology will continue to be a challenge. Lack of homogeneous solution will always result in inefficiency in the smart grid.
- Operational requirements of upgrading meters, may change the timing of utility invoices
- Not being able to use all the technologies
- Corporate buy-in, justifying costs due to data is as good as how you react
- Getting the funding to implement the Energy Information System and Energy Management System

has been slow, but now that management has seen the benefit, it's full speed ahead.

Please place general comment(s) about responses to question 8 here:

9. What are the risks associated with the smart grid technologies identified in Question 3?

- Implementation can be expensive and require on-going costs to maintain the Energy Information System and Energy Management System. This might involve service contracts that can be more cost than the benefit from the submetering. So setting up these systems to minimize on-going maintenance cost is very important.
- May give the utility justification in adjusting time-of-use rates in a manner that is not optimal for our consumption requirements and patterns
- IT security
- The data security and accuracy of meter information must be secured

Please place general comment(s) about responses to question 9 here:

10. What *tangible* benefits of *future* smart grid technology adoption do you anticipate?

- Increased efficiency
- We can save some costs.
- Lower costs
- We can become a greener organization.
- Faster speeds and cheaper technologies
- We can introduce our guests to energy savings concepts.
- Monitoring equipment that will integrate with our current monitoring equipment
- Continued improvements on cost management on energy usage, utility costs, etc.
- Lower energy costs. Utility costs are second only to payroll in our expense structure, so very important to us. Lower emissions, harder to 'see' directly, but definitely tangible.
- Future cost savings as a result of adopting smart grid technologies throughout the XXXXX portfolio. Additionally, having more rapid access to our energy consumption data can help us to better identify 'critical' areas by which we can make the steepest reductions. 'Net metering' will foster greater opportunities for the increase in renewable energy sources (however, I'm not sure if you

include net metering as a smart grid technology). Lastly, I believe that having access to usage data during certain times (on-peak, off-peak, etc.) will prove to be extremely beneficial to help determine ways to reduce on-peak consumption.

- Reducing costs and minimizing the carbon footprint of each and every hotel is becoming mandated. Although there is no direct correlation with increased occupancy, eco-responsible behavior is becoming prevalent. Organizations like XXXXX are creating internal organizations such as XXXXX to promote environmental stewardship.
- In certain states, installing smart meters or telemetry allows certain hotels to move off utility pricing to a deregulated tarries where the pricing per kWh/Dth is considerably lower
- The pending introduction of IP addressable appliances (HVAC equipment, refrigerators, etc. will greatly facilitate the connectivity of these devices to the smart grid. The more devices that can connect the greater reductions in kWh consumption can be achieved with minimal disruption to guest comfort.
- Aside from implementation of more submeters and upgrading energy management systems, I'm not aware of any future "smart grid" technologies.
- More efficient management of the entire system theoretically resulting in lower overall costs passed along to consumers via lower rates than would otherwise be implemented
- Benchmarking to industry standards
- Benchmarking costs through proactive management

Please place general comment(s) about responses to question 10 here:

11. What *intangible* benefits of *future* smart grid technology adoption do you anticipate?

- Ability to manage energy consumption from grid to renewable sources
- Convergence of information allowing sustainable solutions promoting industry goodwill. Although these benefits are intangible and difficult to quantify, demand management is helping support reduced costs
- Greater reliability and faster response to outages, better incorporation of renewable energy including distribution generation systems such as rooftop photovoltaics
- A sense of reassurance in that we can more quickly identify abnormalities in energy usage. Also, by reducing energy waste, we know that we will be reducing the strain that we are placing on the environment. This will hold true even more so should renewable energy be incorporated along with the smart grid technology.
- Certain guests (travelers matching particular demographics/psychographics) may appreciate the

environmentally friendly aspects of smart grid technology and perhaps choose to stay at hotels that utilize such business practices.

- Our customer base is smart and educated and they will appreciate the environmentally friendly initiatives that we are undertaking.
- Guest desires for greener operations.
- More vibrant employee interests.
- Positive impact on guests.
- People paying closer attention to consumption of resources in general
- More energy savings
- Lower overall consumption

Please place general comment(s) about responses to question 11 here:

12. Which smart grid technologies do you anticipate may have the greatest benefits? (Exclude currently adopted smart grid technologies, if any)

- None have really taken a dominant leadership position.
- Wireless connectivity to submeters, development of lower cost of metering and energy management system components.
- Any technology that helps peak load management will inherently reduce the total cost of ownership for both the utilities as well as the customer.
- Mobile smart phone shutdown/unplug device controls for appliances
- Despite the level of complaints stemming from the adoption of current smart grid meters at the moment, I believe that the technologies will only improve over time and will provide greater benefits for all users, as long as the users understand how to use the technology.
- The ability to sell renewable energy back into the grid via 'net metering' will be highly beneficial.
- Many benefits to full service hotels with silo'd amenities that require high energy loads - Similar to what we are seeing with appliance use at residential homes.
- Incorporation of a larger portfolio share of renewable energy generation technologies, resulting in lower greenhouse gas emissions

Please place general comment(s) about responses to question 12 here:

13. Which smart grid technologies do you anticipate may have negative impacts? (Exclude currently adopted smart grid technologies, if any)

- Proprietary software/hardware creating a barrier of entry, not having open protocols
- Residential, consumer-based products which are meant to sell more products and thus increase overall resource consumption in exchange for small improvements in efficiency
- Significant demand reduction, load shedding, or time-factor charging, runs counter to guest expectations and competition factors.
- Reduction of guest satisfaction, waters down occupancy, diminishes competitive positioning
- Demand response, if not executed well, can have negative impacts on our guests.
- End-user misunderstanding of new technologies can lead to complications. Additionally, current smart meter technology isn't completely developed (at least compared to what it will be in the future) and questions regarding accuracy is troublesome for the time being.
- Practical deployment is a cause for concern, and unless an implementation plan is clearly defined, the perceived risks could be high.
- For those customers with tendencies to use a greater proportion of energy during peak hours, higher average costs will likely be the result.

Please place general comment(s) about responses to question 13 here:

14. What are the challenges of, or barriers to, *future* smart grid technology adoption?

- Significant demand reduction, load shedding, or time-factor charging, runs counter to guest expectations and competition factors.
- Costs
- Implementation
- Perceived higher cost of entry (new major systems and appliances to benefit from the Smart Grid technologies).
- The current electrical grid infrastructure is unable to handle future load, as well as the inclusion of future renewables and moving renewable energy to areas of the country that cannot produce as much renewable energy. The main barrier to expanding and improving the grid will be of a financial nature. A big supplier of these funds is the federal government. Without subsidies and/or rebates,

creating a smart grid will become increasingly more difficult. Current austerity measures being discussed in Congress will delay the roll-out of the smart grid, so that may in fact be the greatest barrier.

- Old legislation at different levels of government
- Interests from coal companies
- Education. Quite simply, the messaging needs to be at the right level for the audience making the decision on this technology.
- There are many challenges of technology adoption. The utility industry has a myriad of different systems that are operated in unique and distinct manner. This uniqueness results in lack of homogeneous/scalable solutions that adds significant costs in developing these smart grid solutions. If the technology platform [. . .]
- Equipment replacement cycles may preclude technologies from being adopted in the immediate future.
- The public perception of greater central control of consumption
- Higher rates
- Sources of capital to deploy large scale enhancements to the entire system

Please place general comment(s) about responses to question 14 here:

15. What risks may be associated with *future* smart grid technology adoption?

- Reduction of guest satisfaction, waters down occupancy, diminishes competitive positioning
- Cost
- Increased wireless transmission, which could be harmful to human health
- Any early failures that either grab news headline or worse, harm human lives in some way will immediately put a block on the technology
- Ageing infrastructure
- Data Security
- Cyber security issues need to be addressed.
- Access to data, need to ensure that data/access does not get in wrong hands

- Early results may not be aligned with expected savings which may inhibit future investments.
- There is a risk that electrical grid infrastructure will not be able to evolve as quickly as the technology, wasting a precious opportunity to take advantage of this technology to reduce our dependence on fossil fuels.
- There is a slight risk that more accurate energy readings can lead to higher costs, which in turn can lead to rejection of the technology from consumers.
- Unproven technologies
- Reliability

Please place general comment(s) about responses to question 15 here:

16. Please identify the smart grid technologies you anticipate will be adopted by the end of the year 2020.

- Real time metering to allow for true real time pricing, tied to localized distributed generation that can be dispatched at pre-determined points (i.e. if the hourly price of electricity is greater than $xxx.xx/mWh, then dispatch a fuel cell and disconnect me from the grid).
- Greater controls for demand response (controlling down to specific loads, rather than "banks" of loads)
- "Smarter" Building Automation Systems (BAS) - able to either monitor grid conditions and/or market conditions
- I'm not sure that we would change anything that we are currently doing now. We have a good system that meets our needs for the lowest implementation cost and on-going maintenance cost.
- Open protocol monitoring
- Automotive, residential, commercial, appliance, demand response
- Smart meters will [be adopted by] a greater proportion of the general population, though I do not see them as being made available to all Americans.
- Smart meters
- 'Net metering,' depending on the availability and usage of renewable energy sources, but much less so than smart meters
- Digital communications deployed throughout generation and distribution system

Please place general comment(s) about responses to question 16 here:

17. Which of the smart grid technologies identified in Question 16 do you anticipate will be adopted by the end of year 2015?

- Demand Response controls
- Building Automation System technology
- Smart meters, but less widespread as in 2020
- 'Net metering,' depending on the availability and usage of renewable energy sources, but much less so than smart meters, and less widespread than in 2020
- More metering and more energy management system installations. We are implementing now and by 2015 we'll just have more.
- Open protocol monitoring
- Deployment of smart meters to every customer

Please place general comment(s) about responses to question 17 here:

---

18. First Round Comments:

- More intelligent control and detailed information in both the hands of consumers and utilities should allow for a better overall system
- Our company is 100% franchised...meaning that each and every one of our domestic hotels is individually owned and operated. Therefore, our ability to mandate or govern the use of Smart Grid Technology (or any energy management solution) is extremely limited.

Please place general comment(s) about first round comments here:

THANK YOU!

Appendix F

DELPHI THIRD ROUND INTRODUCTORY LETTER

UNIVERSITY OF DELAWARE | Alfred Lerner College of Business & Economics

DEPARTMENT OF HOTEL, RESTAURANT & INSTITUTIONAL MANAGEMENT

Dear (Industry Expert Name):

Thank you for continuing to participate in my research study. I am happy to report that we are moving into the home stretch - the third, and final, round of the study. **The purpose of the third round is to reach consensus by ranking issues identified and clarified in the first and second rounds**. There are seventeen questions, mirroring the seventeen questions in the first and second rounds. After assessing several methods, I chose Qualtrics survey software for the third round. Survey links are not my favorite method of communicating – they seem impersonal – but the software makes completing the final round a user friendly experience, minimizing time and effort. The questions are in survey format, not in open-ended format as in previous rounds, so you just click and move on with this one!

Please be advised that the software will not allow you to submit your survey until all questions have been responded to. If you miss anything, the software will direct you to the missing piece.

Please return the third round by **Thursday, March 24**. If this time frame is not realistic for you, please let me know as soon as possible. This is the final segment of the study "conversation" with your peers, and it's important that you have ample time to weigh in.

Many, many thanks for your time and attention. Please don't hesitate to call with questions. I'm looking forward to receiving your third round!

Best regards,

Diane M. Vondrasek
MS Candidate
Hospitality Information Management
Lerner College of Business & Economics
University of Delaware
Raub Hall
14 W. Main St.
Newark, Delaware 19716
USA

Appendix G

DELPHI THIRD ROUND INSTRUMENT

Study participants identified the following technologies as smart grid technologies that may apply to the U.S. lodging industry.

Please choose the best description of how useful you believe each technology is in the U.S. lodging industry.

	Useless	Slightly Useful	Somewhat Useful	Useful	Very Useful
Data acquisition servers					
Demand response technology/peak demand reduction					
Digital, two-way communications with utility					
End-user (guest room) energy management technologies					
Energy information systems					
Energy management systems					
Load shifting					
Property management systems					
Smart meters					
Sub-metering					

Study participants identified the following methods by which they became aware of smart grid technologies.

Please choose the level of effectiveness that best describes your experience with each method.

	Not Effective	Slightly Effective	Somewhat Effective	Effective	Very Effective
Energy information technology vendors					
Energy information technology industry trade shows					
Energy information technology industry joint projects					
Individual research - internet search					
Individual research - print articles and publications					
In-house staff knowledge base					
Inquiries from lodging properties/companies					
Interaction with local utility personnel					

Local general news	○	○	○	○	○
Local utility news	○	○	○	○	○
Lodging industry publications	○	○	○	○	○
Lodging industry trade shows	○	○	○	○	○
Personal contacts in the lodging industry	○	○	○	○	○
Public utility commission filings	○	○	○	○	○
Utility industry articles and publications	○	○	○	○	○

Study participants identified the following smart grid technologies as having been currently adopted in their lodging properties, companies, or client companies.

Please choose the best description of the usefulness of each technology in the U.S. lodging industry.

	Useless	Slightly Useful	Somewhat Useful	Useful	Very Useful
Custom, web-based, energy information systems that provide feedback to customers on their energy usage	○	○	○	○	○
End-user (guest room) energy management systems with peak demand reduction response capabilities	○	○	○	○	○
Enterprise energy management systems that control facility HVAC and lighting based on time schedules and temperature setpoints	○	○	○	○	○
Gas line telemetry allowing properties to go off utility pricing	○	○	○	○	○
Remote, wireless, monitoring equipment	○	○	○	○	○
Smart meters capable of measuring consumption in 15 minute intervals	○	○	○	○	○
Smart meters with two-way communications with utility companies	○	○	○	○	○
Technologies that provide daylight harvesting capabilities	○	○	○	○	○
Technologies that provide demand response capabilities	○	○	○	○	○
Technologies that provide load shedding capabilities	○	○	○	○	○
Technologies that provide net-metering capabilities	○	○	○	○	○

Study participants identified the following tangible benefits of *currently adopted* smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Income received from utility company incentives for participation in peak load reduction programs.					
Lower energy costs as a result of better load management					
Lower energy costs as a result of the ability to track and benchmark energy use					
Lower energy costs as a result of end-user (guest room) energy management systems					
Lower energy costs as a result of time-of-use management					
Lower energy costs as a result of peak demand shaving strategies					
Reduced payback periods for energy management systems					

Study participants identified the following intangible benefits of *currently adopted* smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Ability to monitor progress and track improvement					
Better comfort conditions for employees					
Better comfort conditions for guests					
Environmental conservation					
Guests may be stimulated to consume less when they can compare their consumption against other rooms or averages					
More reliable overall service from utility companies because of greater efficiencies in managing generation and distribution					
Opportunity to advertise green efforts thus attracting groups who prefer those types of properties					
Opportunity to advertise green efforts thus attracting individual travelers who prefer those types of properties					
Sustainability/ public relations					

Study participants identified the following *currently adopted* smart grid technologies as having the greatest benefits in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Energy management systems	○	○	○	○	○
Remote monitoring technologies	○	○	○	○	○
Technologies capable of identifying detailed levels of peak vs. non-peak consumption	○	○	○	○	○
Technologies that provide scheduled load shedding	○	○	○	○	○

Study participants identified the following *currently adopted* smart grid technologies as having negative impacts in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Cost to implement Energy information and Energy management systems	○	○	○	○	○
Creating a false sense of savings that would cause staff to poorly manage their property and create "usage creep"	○	○	○	○	○
Equipment failure due to incompatible controls	○	○	○	○	○
Possibly all-if smart grid technology implementation strategy is poorly executed it may result in negative environmental impact	○	○	○	○	○
Possibly all - the temptation to "greenwash" is common	○	○	○	○	○
Utility companies may use smart grid technologies as justification to adjust time-of-use rates in a manner that is not optimal for lodging property consumption requirements and patterns	○	○	○	○	○

Study participants identified the following challenges of *currently adopted* smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

Assessing benefits vs. expense					
Corporate buy-in/justifying costs to get data. Data is only as good as how you react to it					
Creating a plan and implementation strategy					
Integration of technology/lack of homogeneous solutions					
ROI for properties with less than 200 rooms is undocumented					
Service contracts/costs of maintaining technology systems					
Up-front expenditures are unrealistic for many owners of smaller properties because many new technologies are initially developed for properties with 200 rooms or more					

Study participants identified the following risks of *currently adopted* smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
IT security					
Meter accuracy					

Study participants identified the following tangible benefits of *future* smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Company benchmarking					
Faster speeds enabling identification of "critical" areas by which we can make steep reductions.					
Industry benchmarking					
Introducing guests to energy savings concepts					
Less expensive equipment integration					
Lower energy costs					
Lower emissions					
Lower installation costs					
Lower equipment costs					

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Minimal disruption to guest comfort as a result of IP addressable appliances (HVAC equipment, refrigerators)	○	○	○	○	○
New technologies will help satisfy government mandates and avoid potential fines	○	○	○	○	○
Property benchmarking	○	○	○	○	○
Some hotels will be able to move off utility pricing to deregulated tariffs where the pricing is significantly lower	○	○	○	○	○
Utility rebates/subsidies	○	○	○	○	○

Study participants identified the following intangible benefits of *future* smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Ability to manage energy consumption from grid with in-house renewable resources	○	○	○	○	○
Ability to quickly identify energy usage abnormalities	○	○	○	○	○
Becoming a greener organization	○	○	○	○	○
Certain guests (travelers matching particular demographics/psychographics) may appreciate the environmentally friendly aspects of smart grid technology and choose to stay at hotels that use the technologies	○	○	○	○	○
Faster outage response	○	○	○	○	○
Guest desires for greener operations	○	○	○	○	○
Guest expectations for greener operations	○	○	○	○	○
Incorporation of renewable energy	○	○	○	○	○
Industry goodwill through convergence of information allowing sustainable solutions	○	○	○	○	○
Improved reliability	○	○	○	○	○
More vibrant employee interests	○	○	○	○	○
Positive impact on guests	○	○	○	○	○

Study participants anticipate the following *future* smart grid technologies may have the greatest benefits in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Mobile applications such as smart phone shut down device controls for appliances	○	○	○	○	○
"Net metering" that enables the sale of renewable energy back onto the grid	○	○	○	○	○
Peak load management technologies	○	○	○	○	○
Technologies that enable reduction of high energy loads of siloed amenities	○	○	○	○	○
Technologies that facilitate a larger portfolio share of renewable energy generation	○	○	○	○	○
Technologies with wireless connectivity	○	○	○	○	○

Study participants anticipate the following *future* smart grid technologies may have negative impacts in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Proprietary software/hardware, not having open protocols	○	○	○	○	○
Significant use of demand reduction, load shedding, or time-factor charging related technologies runs counter to guest expectations, reduces guest satisfaction and diminishes competitive positioning.	○	○	○	○	○

Study participants identified the following challenges of, or barriers to, *future* smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Education - the message needs to be at the right level for the audience making the decisions on smart grid technologies	○	○	○	○	○
End-user (guest) misunderstanding of new technologies can lead to a diminished guest experience	○	○	○	○	○
Equipment replacement cycles may preclude immediate smart	○	○	○	○	○

grid technology adoption					
Fast technology advancement. It's expensive to keep up. The solution yesterday is not the solution today					
Lack of homogeneous/scalable solutions adds significant cost to smart grid technology adoption					
Outdated legislation at various levels of government					
Perception of greater central control of energy consumption					
Perceived higher cost of entry (new major systems and appliances required to benefit from the smart grid technologies)					
Practical deployment					
Regulatory inconsistency. There are no "overall guidelines/rules" between regulated utilities. A technology considered safe and cost effective by one regulatory body could be considered dangerous and/or burdensome by rate payers in another.					
Sources of capital to deploy large scale enhancements to the entire system.					
U.S. "one size fits all" federal policy vs. facilitating "distributed generation sources" (micro-grids) in specific areas					
Utility industry failure to fix grid infrastructure					

Study participants identified the following risks of *future* smart grid technologies in the U.S. lodging industry.

Please choose the extent to which you agree or disagree.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Cyber security					
Data Security					
Early results may not align with expected savings which may inhibit future investments					
Reliability					

Study participants anticipate the following smart grid technologies will be adopted in the U.S. lodging industry by the end of year 2015.

Please indicate how likely you believe it is that each technology will be adopted in the U.S. lodging industry by the end of year 2015.

	Unlikely	Slightly Likely	Somewhat Likely	Likely	Very Likely
Building automation systems that manage on a second-by-second basis (e.g. a hotel receives a request from the utility to reduce consumption by X for the next 2 hours. The system will first identify unrented rooms, open the energy bands, thus ensuring no energy will be consumed by the HVAC in those rooms. Then it will identify rented but unoccupied rooms and apply the same strategy)	○	○	○	○	○
Demand Response Controls	○	○	○	○	○
"Net Metering" (dependent on the availability and usage of renewable energy sources)	○	○	○	○	○
Open protocol monitoring	○	○	○	○	○
Smart meter deployment to every customer	○	○	○	○	○

Study participants anticipate the following smart grid technologies will be adopted in the U.S. lodging industry by the end of year 2020.

Please indicate how likely you believe it is that each technology will be adopted in the U.S. lodging industry by the end of year 2020.

	Unlikely	Slightly Likely	Somewhat Likely	Likely	Very Likely
Appliance demand response	○	○	○	○	○
Automotive demand response	○	○	○	○	○
Improved demand response controls (controlling down to specific loads, rather than "banks" of loads)	○	○	○	○	○
"Smarter" building automation systems, with real-time metering, capable of monitoring grid conditions and/or market conditions, tied to localized distributed generation that can be pre-dispatched at pre-determined points (i.e. if the hourly price of electricity is greater than $xxx.xx/mWh, then dispatch a fuel cell and disconnect from the grid)	○	○	○	○	○
Technologies capable of providing communication with generation plants all around the continent.	○	○	○	○	○

>>

Appendix H

DELPHI THIRD ROUND FOLLOW-UP LETTER

Dear (Industry Expert Name):

By now you will have received the third round survey - at least that's what the survey software is indicating! If you have not received the third round survey, or if you are unable to complete it by Thursday, March 24, please let me know as soon as possible. Your contributions are important, and I want to be sure you have ample time to complete the survey.

I am enjoying analyzing survey responses submitted so far - it's very exciting - you and your fellow participants never fail to confirm your "Awesome SGT Study Participants" identity in the UD HRIM Department!

Thank you for your time and attention.

Best regards,

Diane M. Vondrasek
MS Candidate
Hospitality Information Management
Lerner College of Business & Economics
University of Delaware
Raub Hall
14 W. Main St.
Newark, Delaware 19716
USA