COLLEGE OF ENGINEERING & COMPUTER SCIENCE
Department of Civil Engineering
777 Glades Road, ENG 213
Boca Raton, FL 33431
tel: 561.297.0466, fax: 561.297.0493
www.civil.fau.edu

Florida Atlantic University
Department of Civil Engineering

“Green Lodging Project Phase 2:
Energy Efficiency and Clean Air Practices”

-FINAL REPORT-

D.E. Meeroff, Ph.D. and P.D. Scarlatos, Dr.-Eng.
Florida Atlantic University, Department of Civil Engineering
777 Glades Road 36/222, Boca Raton, FL 33431-0091
(561) 297-3099 ▪ (561) 297-0493 (FAX)

Laboratories for Engineered Environmental Solutions

March 31, 2007

Executive Summary

It has been documented that the Green Lodging Certification Program practices are generally effective in reducing multi-media waste streams and thus resulting into a cleaner environment, financial benefit, and positive publicity to the participating hotel businesses. Green Lodging practices are applied with respect to (a) water conservation, (b) solid waste management and waste reduction, (c) energy efficiency, and (d) clean air practices.

This study is the first part of a two phase project. Both phases are comprised of two parts: (1) critical literature review/data collection part, and (2) implementation, where hotels are selected for application of Green Lodging practices and monitoring of its performance measures. The first phase focused on (a) water conservation and (b) solid waste management and waste reduction, while the second phase includes: (a) energy efficiency and (b) clean air practices.

This report contains a critical literature review and data analysis regarding (a) energy efficiency and (b) clean air practices obtained from the lodging sector. Data are collected from a plethora of sources but the emphasis has been focused on experiences from the State of Florida. However, nationwide and worldwide data were also included for comparison, and were found to be in agreement with the beneficial results identified through the Florida Green Lodging program.

Best management practices are also discussed in detail for each specific area of a hotel such as: main lobby/office, guest rooms/housekeeping, laundry, kitchen/restaurant/bar, conference areas/meeting rooms, grounds, and swimming pool/spa. The report also provides resources and information to disperse some common misconceptions of the hotel industry regarding: (a) perceived lack of information and resources about environmental options, (b) perceived lack of ability to research the environmental performance of hotels, and (c) perceived prohibitive cost issue.

Table of Contents

List of Figures

List of Tables

Description of Approach

Introduction

The Florida Green Lodging Certification Program (FGLCP) is an effort by the Florida Department of Environmental Protection (FDEP) to encourage the tourist industry to conserve and protect Florida's natural resources. Under this program, hotels and motels have been able to help protect the environment, while saving money and generating positive publicity. The purpose of this study is to identify the factors that affect or influence the performance of environmental programs for FDEP Green Lodging Certification. With this information, more cost-effective measures can be identified and implemented. Florida is one of only a handful of states to implement a green lodging program. Others include California, which began its program in 2003, Vermont, which established its program in 1999, and Michigan and Wisconsin, which are conducted pilot phases.

According to the Travel Industry Association of America, business travel expenditures totaled $185 billion in 2000, with $37 billion spent on accommodations alone for 2.6 million rooms per day (CERES 2006). The lodging industry uses an estimated 180-250 billion gallons of water per year (Hemmila 1998; Abt Associates Inc. 2001), generates 0.6-2.8 million tons of solid waste annually (NCDENR 1998; Abt Associates Inc. 2001), and uses the fourth most electricity within the commercial sector. Nationwide, the lodging industry comprised over 51,000 facilities with over 3.1 million rooms in 1999 according to Patricia Griffin of the Green Hotels Association (quoted in Davies and Cahill 2000). According to the Florida Department of Business and Professional Regulation (www.myflorida.com/dbpr), as of March 2005 there were 398,322 hotel, motel and bed-and-breakfast rooms in Florida spread over 4,948 properties. Resort condos and dwellings add another 97,459 units from 10,177 properties. All together, they serve about 35-40 million guests annually, contributing over $14 billion to the local economy (VisitFlorida 2006). The lodging industry is responsible for generating 4% of the state's municipal solid waste per year, uses 625 million kWh of electricity, and consumes billions of gallons of water (Yon 2005).

Project Description

Candidates for Green Lodging Certification require information regarding performance measures for: 1) water conservation, 2) solid waste management and waste reduction, 3) energy efficiency, and 4) clean air practices. This study is proposed to be conducted in 2 phases, corresponding to the first two and the second two numbered performance areas described above, respectively. Once this information is made available, candidate facilities can target and implement specific measures that provide the maximum return on the investment in terms of reduced water and energy demands, pollution prevented, and indoor environments protected. Results will provide a clear understanding of currently available practices and their environmental and economic benefits as well as future conservation initiatives needed to maximize the impact of the Green Lodging Certification Program.

The study will be conducted in phases corresponding to the two sets of target areas described above. The scope of work for Phase 1 (solid waste management/waste reduction and water conservation) was completed in June 2006. Phase 2 is similarly structured but will focus on energy efficiency and clean air practices. The scope of work for Phase 2 is described below.

Phase 3 will focus on implementation of waste minimization, water conservation, energy efficiency, and indoor air quality projects.

An objective of this research is to review the cost and effectiveness of existing energy efficient and clean air technologies and strategies implemented by utilities/municipalities or other Green Lodging programs in other states. This review will include the following:

- The cost and effectiveness of existing energy systems and indoor air quality technologies and strategies implemented by utilities/municipalities or other Green Lodging programs in other states.
- Costs for traditional strategies;
- Costs for newer best management practices;
- Energy usage values for traditional fixture type or appliance;
- Energy usage values for newer low-flow fixture type or appliance;
- Legal, policy and social barriers to implementation of conservation measures;
- Staff training requirements;
- Cost savings expected from implementation of best management practices in the energy sector that may be implemented as a result of this study.

Energy Efficiency

Hotel, motels, and bed-and-breakfast facilities face unique challenges regarding energy management. For instance, the property may be active 24 hours a day and may comprise more than one building. In addition, guest behavior is difficult to control. For instance, guests are often allowed to adjust their own thermostat settings, use large amounts of hot water, leave doors and windows open while the cooling or heating system is running, and leave lights or television sets on in unoccupied rooms. This can greatly increase the amount of energy consumed, and thereby increase operating costs, without additional revenue.

According to the Energy Information Administration Commercial Buildings Energy Consumption Survey (EIA 2004), in 2003 the lodging industry accounted for 8% of all energy sources in the USA. Of the 1,017,221 billion Btu used by the commercial sector in 2003, the lodging industry was responsible for 24 billion kWh of electricity usage or nearly 2.4 billion dollars each year in energy bills, using the Florida average of 9.90 cents/kWh (Oct 2006). This is down from 1999 estimates that put the lodging usage at 57 billion kWh and 5.2 billion dollars annually (EIA 2003). If these numbers are accurate, then the lodging industry has already reduced its energy demand by half over the past decade. However, an additional 10-30% reduction is realistically attainable given current technologies and energy minimization strategies. Better management of energy performance will allow Florida's lodging industry to achieve substantial savings in operating costs, as well as decrease its impact on natural resources. Improving energy efficiency can achieve the desired outcome of reducing costs without reducing customer satisfaction.

Energy Use

Before targeting certain technologies for reducing energy consumption, it is important to determine which activities are responsible for the majority of the energy usage in a typical hotel. Table 1 contains a summary of energy usage data for the hotel and lodging sector. Two studies (EIA 1999; EIA 2003) involved data from the Commercial Buildings Energy Consumption Survey (CBECS) in 1995, released in July 1998, by the Energy Information Administration and then updated with 1999 data in 2003. These data represent estimated annual energy consumption from 315 (of 127,400) U.S. lodging sites in existence at the time. Two others were done in Canada (Fecteau 2005; Environment Canada 2004). The Michigan study (Michigan DL&EG 2006) was focused on hotels located in the Midwest United States. The PA Consulting Group (2001) study was international and focused primarily on small hotels. Two of the studies were Florida-specific (Miller 1984; FPL 2004). Miller (1994) reported data that was collected more than ten years ago, while the FPL (2004) study is more recent. Analyzing the data available, it is clear that location, size, amenities, and climate play an important role in dictating the breakdown of energy consumption at hotels and motels.

Since a wide distribution of energy usage is available, it was desired to look more closely at the Florida-specific data from the FPL (2004) study. This is shown in Figure 1. From the data, it is clear that air conditioning and lighting alone, account for 70% of total electricity usage in hotels and motels in Florida. Comparing the overall average US data and the international studies (Table 1) to the FPL values shows a clear juxtaposition of the space heating category for the space cooling category, which dominates the energy demand in Florida. Since air-conditioning and lighting account for nearly three-quarters of a typical hotel's energy usage, opportunities for reducing electricity consumption in these major areas will generate considerable energy and cost savings without sacrificing guest satisfaction.

Table 1. Summary of energy consumption breakdown

Usage Sector	Percent of Total	Reference
Water Heating	1%	FPL 2004
	38.5%	Miller 1994
	14%	Michigan DL&EG 2006
	9%	PA Consulting Group 2001
	41%	EIA 2003
	5%	EIA 1999
	15%	Fecteau 2005
	11%	Environment Canada 2004
Lighting	23% (including 4% exterior lighting)	FPL 2004
	17.5%	Miller 1994
	16%	Michigan DL&EG 2006
	9%	PA Consulting Group 2001
	20%	EIA 2003
	23%	EIA 1999
	33%	Fecteau 2005
	10%	Environment Canada 2004
Space Heating	1%	FPL 2004
	26%	Michigan DL&EG 2006
	16%	EIA 2003
	11%	EIA 1999
	33%	Fecteau 2005
	51%	Environment Canada 2004
Space Cooling	47%	FPL 2004
	30.5% (includes space heating)	Miller 1994
	31% (+4% for refrigeration; +5% for ventilation)	Michigan DL&EG 2006
	64%	PA Consulting Group 2001
	6% (+2% for refrigeration; +1% for ventilation)	EIA 2003
	40% (+6% for refrigeration; +7% for ventilation)	EIA 1999
	8%	Fecteau 2005
	6% (+8% for auxiliary motors)	Environment Canada 2004
Cooking	3%	FPL 2004
	6.3% (includes refrigeration)	Miller 1994
	8%	Michigan DL&EG 2006
	12% (+3% icemaking; +2% exhaust fans)	PA Consulting Group 2001
	4%	EIA 2003
	1%	EIA 1999
	9%	Fecteau 2005
	Not Reported	Environment Canada 2004
Office Equipment	1%	FPL 2004
	3%	EIA 2003
	7%	EIA 1999
	Not reported	Fecteau 2005
	15% (includes auxiliary equipment)	Environment Canada 2004
Miscellaneous	24% (10% ventilation; 5% motors)	FPL 2004
	7.2%	Miller 1994
	5%	Michigan DL&EG 2006
	6% (+2% pool pumps)	PA Consulting Group 2001
	6%	EIA 2003
	13%	EIA 1999
	Not reported	Fecteau 2005
	Not reported	Environment Canada 2004

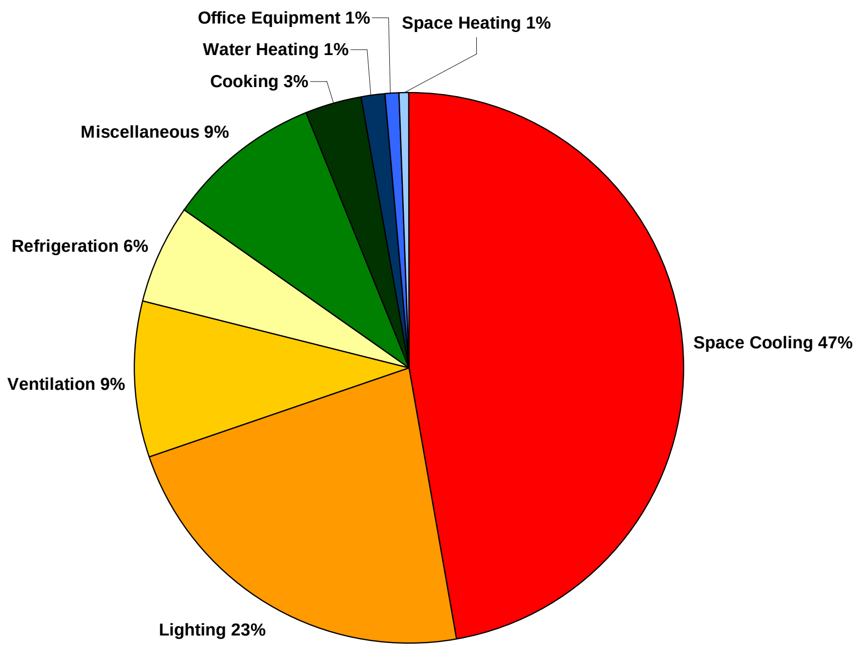

Figure 1. Breakdown of Annual Energy Consumption End-Uses for the Lodging Industry in Florida. Data obtained from FPL (2004).

Costs and Savings

Energy savings means cost savings. This parameter is readily quantifiable. From the utility bill, the kWh and the unit cost for electricity are reported monthly and can be easily tracked; assuming that the utility does not apply an annual averaging cost strategy to reduce its meter reading frequency, in which case, maintenance personnel can record the monthly meter reading in a logbook to track the benefits and cost savings of energy reduction strategies.

Most utilities charge commercial buildings based on the amount of energy delivered, but electricity can be charged based on consumption or demand. The consumption component of the bill is the amount of electricity, in kilowatt-hours (kWh), that the building consumes during a month. The demand component is the peak demand (in kilowatts) occurring within the month or, for some utilities, during the previous several month period. Using a national average electricity cost of 10 cents per kWh, a rule of thumb is for every 1,000 kWh saved by energy conservation practices equals $100 off the utility bill.

In the United States, hotels larger than 8000 ft^2 spend about \$1.05/ft^2 annually on electricity bills. Hotel energy costs can consume from 4 – 10% of a property's total revenue, which may be more than the profit margin in many instances (E Source 2004). According to GE Consumer and Industrial Lighting, the lodging industry nationwide spends $1.41 per square foot on energy annually, with hotel utility costs averaging approximately 3.9% of total revenue. If hotels across the country improved their energy performance by an average of 30%, the annual electricity bill savings would be nearly $1.5 billion[1]. This represents an annual savings of $365 for every hotel room in the country.

Energy Star® Award winner *Starwood Hotels & Resorts Worldwide, Inc*. was able save to $3.4 million in energy costs, equivalent to renting 9,370 additional rooms, by implementing an energy management program (www.energystar.gov). Closer to home, the annual savings would be on the order of $125 – $155 per room in Florida, based on the annual consumption of 625 million kWh for the lodging industry and using the number of hotel, motel, and bed-and-breakfast rooms in the State in 2005. According the Hospitality Research Group of PKF Consulting, a 10% reduction in energy costs is equivalent to increasing occupancy points by 1.04 and increasing average daily rates by 1.6% for a full-service hotel (cited in Hinton et al. 2004). Every dollar in energy savings is equivalent to increasing operating margins by $2 – $3.

According to data published in the Wisconsin “Focus on Energy” program, mid-scale hotels without food and beverage service average 7342 kWh/yr/room, while budget motels average 6788 kWh/yr/room. Another source indicated that these numbers vary much more, at 16 – 100 kWh/guest/night (or 7300 – 36,500 kWh/yr/room) (Baldinger 2006). Closer to home, data obtained from 11 Orlando area hotels revealed that the amount charged to the electric bill ranges from $0.80 - $4.52 per night (Burkett 2007). If a rate of $0.10/kWh is assumed, then these latest numbers are on the order of 2920 – 16,500 kWh/yr/room.

At most small hotels in the Caribbean, there are significant low-cost, high payback opportunities for energy conservation that can lead to a reduction in energy use of 10 – 25%. At a typical hotel, an investment in energy conservation of approximately $20 – $30 per room will yield an annual savings of over $100 per room, giving a one-year return on investment (ROI) of 300%. For example, an environmental assessment at Blue Waters Inn, a 38-room property on the North End of Tobago, identified low-cost energy conservation opportunities that would reduce their energy consumption and costs by 20% (PA Consulting Group 2001).

Success stories of energy conservation programs can be found all over the country, including Florida. This is not something new. For instance, the Hotel Inter-Continental in Miami, FL was awarded the International Hotel and Restaurant Association Environmental Award in 1993. The property is a 34-story executive hotel with 664 rooms, 33 suites, 5 restaurants, and 61,000 ft^2 of meeting space and banquet halls. In terms of energy savings, the hotel participated in a lamp replacement program and programmable thermostat retrofit. Motion sensors were installed in all meeting rooms, air conditioning filters were changed once a month instead of every two months, temperatures in corridors and elevators were adjusted, variable frequency drives were installed on all electric motors, timers were fitted on all energy equipment, and incandescent bulbs (40 watts) were switched for single florescent lamps (34 watts). Collectively these actions saved an estimated 400,000 kWh of energy per year, or $2,400 (in 1993 dollars) (IH&RA 1995).

Environmental Benefits

The benefits of energy efficiency are not financial alone. In many cases, energy savings can be gained in concert with water conservation measures, waste reduction, and improvements in indoor air quality. Furthermore, the 2001 Energy Star® Award Winning Hilton Hotels’ energy management plan resulted in a savings of nearly 43 million kWh of electricity per year and the prevention of 65 million pounds of carbon dioxide (CO_2) emissions. This is the equivalent of

[1] www.energystar.gov/index.cfm?c=hospitality.bus_hospitality

removing 6,450 cars from the road in the year 2000. If we take the 2005 data (EIA 2006) from the Energy Information Administration of the Department of Energy's "Emissions from Energy Consumption for Electricity Production and Useful Thermal Output at Combined-Heat-and-Power Plants," we see that the total amounts of emissions from US power production are as follows:

Table 2. Annual emissions in million metric tons/year and total output in million kWh/year from electricity production in the United States (EIA 2006).

Emission	2005	2000	1995
Carbon Dioxide (CO_2)	2,513.609	2,429.394	2,079.761
Sulfur Dioxide (SO_2)	10.340	11.297	11.896
Nitrogen Oxides (NO_x)	3.961	5.380	7.885
Total Power Output	**4,054,688**	**3,802,105**	**3,353,487**

If we take the total net electricity generation attributed to Florida (220.3 billion kWh in 2005) and use the energy consumption data from the Orlando study (Burkett 2007), we find that Florida's lodging industry is responsible for 0.5 – 3.0% of the usage. Thus if every hotel in Florida were to reduce their energy consumption by just 10%, this would result in the prevention of 72,000 – 407,000 metric tons of carbon dioxide, 300 – 1700 metric tons of sulfur dioxide, and 115 – 650 metric tons of nitrogen oxides to the environment annually. In addition, the avoided energy production would cut down on wastes generated from flue gas desulfurization (scrubbers), particulate collectors (electrostatic precipitators, filter baghouses, cyclones, etc.), and waste heat as well.

Energy Management Planning

An energy management plan is a way for property owners to address reductions in energy demand. Any plan should include a system to collect, analyze, and display data collected from major energy-consuming appliances. This information will help in optimizing frequency and duration of run times for certain equipment. Improving energy performance, through measurable reductions in energy consumption and costs, can provide a low-risk return on the investment, an increase in worker productivity, and improved asset value. Achieving energy performance results requires a commitment from top-level management and an integrated energy management plan for each area or department. The US Department of Energy Federal Energy Management Program (www1.eere.energy.gov/femp) includes the following categories:

1. Identify opportunities
2. Develop an action plan
3. Conduct a detailed feasibility study
4. Promote success

The first step is to conduct an energy audit to assess electricity usage patterns for each department and document seasonal or local site-specific variations. This will allow the management team to identify potential candidates for reduction. Once these areas are identified, new technologies or strategies can be implemented, monitored, and compared to industry benchmarks. By tracking the implementation costs and the savings realized, the management team can evaluate progress and communicate the success from one department or area to another on the property or even use the savings to invest in larger equipment upgrades that can potentially realize even greater savings. Providing and seeking recognition for energy management achievements is a proven step for sustaining momentum and support for the program. Proper planning will help reduce energy use and decrease maintenance costs while maintaining customer satisfaction and worker productivity.

Local utilities, ESCOs (Energy Saving Companies) or engineering firms can also be a resource for successful energy management plans. According to the Florida Energy Extension Service, energy usage in Florida hotels that participated in an active energy management program improved efficiency by an average of 23% (Hinton et al. 2004).

In order to achieve substantial reductions in electricity consumption, it is necessary to adopt an integrated energy management approach. This involves the following strategies:

1. Purchase Energy Star® qualified equipment products
2. Utilize Green Power partnerships
3. Conduct an energy assessment
4. Take advantage of incentive programs

Energy Star®

In 1991, the United States Environmental Protection Agency introduced the "*Green Lights*" program that encouraged organizations to upgrade their existing lighting to more energy efficient lighting systems and controls. The following year, a labeling program was launched, which introduced the Energy Star® brand, which identifies energy-efficient products and promotes energy performance that saves energy and protects the environment (USEPA 2004). The label has been expanded to include new homes, commercial and institutional buildings, residential heating and cooling equipment, major appliances, office equipment, lighting, and consumer electronics. The Energy Star® logo makes it easier for businesses and consumers to recognize products that exhibit exemplary energy performance, save money on power bills, and prevent unnecessary pollution. Making Energy Star® equipment a part of the energy management plan at a hotel can significantly reduce energy consumption.

Appliances with the Energy Star® designation save water as well as energy. The initial cost of such appliances may be higher in some instances, but the life cycle costs are substantially lower. For example, Energy Star® qualified washers use 18-25 gallons of water per load, compared to the 40 gallons used by standard machines. They do this by extracting more water from clothes during the spin cycle. This reduces the drying time and saves energy and wear-and-tear on linens. An Energy Star® qualified dishwasher saves about $100 over its lifetime. The savings comes from using less hot water than conventional models (Hinton et al. 2004).

Green Power Partnership

Green power is electricity that is generated from renewable resources such as: solar, wind, geothermal, biomass, and low-impact hydro facilities. The USEPA has developed a program called the Green Power Partnership to encourage organizations to utilize green power as a part of an integrated environmental management plan. According to the USEPA, the nation's single largest industrial source of air pollution is the generation of electricity, based on the combustion of conventional fossil fuels (USEPA 2004). The lodging industry can do its part to lower its energy consumption and reduce the environmental impacts of conventional electricity generation by beginning to use renewable energy technologies or by supporting Green Power programs, purchasing green credits offsets, or by directly purchasing renewable energy through the local utility or decentralized power systems.

Additional benefits to Green Power are price stabilization and energy security. By entering into long-term agreements, energy pricing can be locked in over the life of the contract. Furthermore, since these sources do not use fuels, the volatile cost of fuel is eliminated from the cost of energy, and since Green Power does not need to be transported, there is no chance of spills occurring. In terms of energy security, renewables eliminate the need to import fuels, thus the energy source is always available, regardless of international geopolitical conflict.

Florida Power and Light Company (FPL) has a Green Power Partnership initiative called the Sunshine Energy® program for residential customers. For an additional charge of $9.75 per month, customers can subsidize the development of new renewable sources of electricity. For every 10,000 customers who sign up, an additional 150 kW of solar power arrays will be built in Florida. The program ensures the purchase of environmental credits worth 1,000 kWh of electricity produced by renewable energy generation facilities, helping to avoid over 8,000 pounds of carbon dioxide emissions each year (www.fpl.com/sunshine). The 2005 Green Power Leadership award was awarded to FPL for this program. This award is sponsored by USEPA and DOE, for recognizing leading national green power purchasers and suppliers for their commitment to developing new renewable energy sources. The program started in 2004 and has about 23,000 customers enrolled (FPL 2004). Presently, there are no plans to offer this program to business or commercial customers.

Energy Assessment

Most energy service providers offer energy audits to assist businesses in implementing energy conservation programs. FPL offers a free comprehensive review of facility energy usage through their Business Energy Evaluation (BEE) program. The review includes the following systems: rate schedule, power usage patterns, building envelope (walls, roof, ductwork, windows, caulking, and weather stripping), HVAC, process systems (motors, air compressor, elevators, conveyors, food preparation, refrigeration equipment, and computers), lighting, water heating, and energy management systems. An account analysis is performed that takes into account site-specific factors, such as weather and occupancy data, to compare energy usage with other customers in the commercial sector and in the lodging industry.

Incentive Programs

Hotels should look for specific rebate programs such as the following:

- Commercial/Industrial Direct Expansion Unit (DX) Program
- Chiller Program
- Thermal Energy Storage Program
- Energy Recovery Ventilator (ERV) Program
- Efficient Lighting Program
- Building Envelope Program
- Packaged Thermal Heat Pump Program

In addition, many utilities offer lower rates for usage during off-peak hours. Hotels should consult with their local electricity service provider to see if "*Time of Day*" rates are offered. This is an incentive program that rewards customers who agree to use appliances during off-peak hours. Regardless of participation in off peak pricing programs, it is recommended to run major energy-consuming electronics during the hours of 8:00 pm - 6:00 am.

Florida Power and Light Company (FPL) offers an additional package called "*Business On Call*." For this incentive program, FPL will temporarily interrupt the air conditioning system of participating customers during periods of peak electricity demand, if required. In return, the participant receives a credit of $2 per ton of air conditioning, per month, from April through October, on their electricity statement, even if FPL is not forced to interrupt service during the billing period. For a 20-ton unit, that totals an annual savings of $280. Because air conditioning cycles on and off during normal operation, customers and employees may not notice the temporary interruption.

A service exists for listing available energy incentive programs at the state and federal level. This service has a webtool for accessing more information from local service providers called the "*Database for State Incentives for Renewables and Efficiency*" (www.dsireusa.org) (Ohlsen 2007). The State of Florida Energy Office (www.floridaenergy.org) also offers incentive programs such as: the Solar Energy Rebate Program, the Renewable Energy Corporate Tax Program (focused on alternative fuel vehicles, infrastructure, and backup power systems), and the Renewable Energy Technology Grant Program.

Federal programs include:

- Energy Efficient Commercial Buildings Tax Deduction
- Business Energy Tax Credit
- Modified Accelerated Cost-Recover System (MACRS) for Green Power
- Alternative/Hybrid/Fuel Cell Motor Vehicle Credits
- Electric Vehicle Tax Credit

Clean Air Practices

People spend from 70 – 90% of their time indoors, and we are discovering that indoor air quality is substantially more polluted than outdoor air (Hetes et al. 1995; Davis and Masten 2004). Concerns with indoor air quality (IAQ) have increased since energy conservation measures were instituted during the 1970s. Because of the energy crisis, there was great interest in weatherizing homes and buildings to minimize the infiltration of outside air and make buildings more airtight and more energy efficient. However, the tradeoff was less ventilation with fresh air, which contributed to the buildup of indoor air contaminants and the discovery of a new disease called "*sick building syndrome*."

IAQ refers to the physical, chemical, and biological characteristics of air in the indoor environment. IAQ impacts both comfort and health. Its effects are often difficult to quantify comparatively because the perception of air quality is strongly influenced by other environmental factors, such as temperature and humidity. IAQ is governed by ASHRAE Standard 62 (2004), as a function of:

- Airborne contaminant sources, concentrations, and transport
- Adverse human health effects
- Engineering controls of airborne contamination

- Maintenance of acceptable temperature, relative humidity, and air velocity (ventilation)

Contaminant Sources

Indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems. There are many sources of air pollution in buildings. These include:

- Combustion sources such as fossil fuels (i.e. oil, gas, kerosene, propane, coal, and wood) and carbon monoxide from stoves, furnaces, space heaters, chimneys, fireplaces, or generators.
- Environmental tobacco smoke (ETS)
- Building materials and furnishings such as asbestos insulation, damp carpeting or gypsum wallboard (mold), VOCs from glues and sealants, cabinetry or furniture containing pressed wood products made with formaldehyde, and carpets or fabrics with styrene butadiene rubber (SBR) latex backing material that contain 4-Phenylcyclohexene (4-PCH).
- Products for cleaning and maintenance, such as degreasers, moth repellants, air fresheners, and disinfectants. According to Sierra Environmental Technologies, Inc. (2006), a typical housekeeper uses over 200 pounds of chemicals per year, of which approximately 60 pounds (30%) are considered hazardous (i.e. toxic, corrosive, reactive, or ignitable) according to the Resource Conservation and Recovery Act (RCRA).
- Personal care products such as cosmetics, aerosols, and perfumes.
- Central HVAC and dehumidification devices. Inadequate ventilation leads to the buildup of carbon dioxide and other indoor air pollutants like freon.
- Paints, varnishes, waxes, lacquers, paint strippers, paint thinners, dry-cleaning solvents, and other solvents.
- Office equipment such as copiers and printers (inks and ozone), correction fluid, and permanent markers, just to name a few.
- Outdoor air pollution sources such as radon, dust, particulates, pollen, and other allergens. Radon contamination exhibits no immediate symptoms; however, exposure is estimated to contribute to between 7,000 and 30,000 lung cancer deaths each year (USEPA and USCPSC 1995). Based on a national residential radon survey completed in 1991, the average indoor radon level is 1.3 picocuries per liter (pCi/L). The average outdoor level is about 0.4 pCi/L (USEPA and USCPSC 1995).
- Idling vehicle exhaust from shuttle buses, gasoline-powered golf carts, or lawn mowers (unburnt hydrocarbons, NO_x, SO_2, CO, etc.).
- Biological contaminants such as *Legionella* and other bacteria, spores, mold, dust mites, bed bugs, pests, insects. Pets are also a source of biological contaminants, animal dander (skin flakes, fur, etc.), and other allergens.

Health and Environmental Effects

Impacts to human health can be directly or indirectly related to the indoor air pollutant sources described in the previous section. The Institute of Medicine (2004) reviewed the health effects of damp buildings and determined that the most effective way to combat mold and other moisture-related indoor air quality issues is to reduce or eliminate dampness in buildings. The study also concluded that there is a significant association between damp indoor spaces and asthma attacks, allergic reactions, and respiratory ailments in sensitive populations. This represents up to 20% of the population of hotel guests and staff (Harlos 2006). Other health effects were also evaluated. These include but are not limited to the following conditions:

1. Sick building syndrome
2. Acute respiratory problems (caused by chlorine vapors, mold spores, etc.)
3. Hypersensitivity pneumonitis
4. Humidifier fever
5. Asthma
6. Allergies and allergic reactions
7. Legionnaire's disease (caused by exposure to *Legionella*) and other infectious airborne diseases
8. Chronic respiratory sinusitis (Ponikau 1999)
9. Multiple chemical sensitivity
10. Migraine headaches (vapors)
11. Conjunctivitis (ocular eye infections, from irritants) and eye, nose, throat irritations
12. Asbestosis (fatal lung scarring caused by asbestos from buildings built prior to 1980)
13. Mesothelioma (cancer of the chest and abdominal linings)
14. Central nervous system disorders (CNS)
15. Dermal effects (rashes)
16. Dizziness, nausea, disorientation, fatigue, and memory impairment
17. Liver and kidney damage from toxicants

Adverse human health effects from indoor/outdoor air pollutants may be experienced soon after exposure or, possibly as in the case of cancer, many years later. Immediate effects may show up after a single exposure or repeated exposures. These include irritation of the eyes, nose, and throat (respiratory tract), headaches, dizziness, fatigue, and many allergic reactions. Acute effects are usually short-lived and treatable. Simply eliminating or reducing exposure to the source of the pollution, if it can be identified, can be effective at reducing the risk of acute respiratory effects. Symptoms of some diseases, including asthma, hypersensitivity pneumonitis, and humidifier fever, may also show up soon after exposure to indoor air pollutants. On the other hand, symptoms of sick building syndrome can disappear shortly (i.e. hours) after leaving the premises (FEES and Cook 1995).

The likelihood of immediate reactions to indoor air pollutants depends on several factors. Age and preexisting medical conditions are two important influences for acute onset. In other cases, reactions are more related to individual sensitivity, which varies widely from person to person. Some people can become sensitized to biological or even chemical pollutants after repeated exposures. Some effects may be made worse by an inadequate supply of outdoor air or from the heating, cooling, or humidity conditions prevalent. Certain immediate effects are similar to those symptoms generally associated with colds or other viral diseases, so it is difficult to determine causality with respect to exposure to indoor air pollution. For this reason, it is important to pay attention to the time and place the symptoms occur.

Other health effects may show up either years after exposure has occurred or only after long or repeated periods of exposure. These effects, which include some respiratory diseases, heart disease, and cancer, can be severely debilitating or fatal. It makes sense to improve the indoor air quality even if symptoms are not observed, as a preventative measure.

While pollutants commonly found in indoor air are responsible for many harmful effects, there is considerable uncertainty about what concentrations or periods of exposure are necessary to produce specific health problems. People also react very differently to exposure to indoor air pollutants. Further research is needed to better understand which health effects occur after exposure to the average pollutant concentrations and which effects are attributable to the higher concentrations that occur for short periods of time.

Biological Contaminants. One of the most notorious incidents involving building related illness in the mid 1970's was associated with the Mayflower Hotel in Philadelphia, PA, where a conference of the American Legionnaires was held. Several attendees died from bacterial infections spread by the building's HVAC system. The condition is now known as Legionnaires' disease, and the microorganism responsible is called *Legionella*. In 1992 there was an incident of Legionnaires' disease in a Luxury Hotel in central Florida, which caused almost $750,000 loss in canceled business (FEES and Cook 1994). Legionnaires' disease is transmitted in water droplets (from showers typically) or inhaled in aerosols. The bacteria grow in warm water systems like condensate trays and can be spread via the HVAC system. They can also grow in stagnant potable water distribution pipes in biofilm layers that get mobilized when a little used water fixture gets turned on after a prolonged period without use (Meeroff and Bloetscher 2006). Once a carrier is infected, the disease can be transmitted person-to-person.

Legionella and other bioaerosols can be eliminated by looping plumbing dead ends, cleaning and inspecting hot water tanks annually, running hot water circulation pumps, eliminating recycling to mixing valves, storing hot water at 140ºF and delivering at 122ºF, and flushing potable water systems regularly (Harlos 2006).

Mold Issues. Buildings with many water outlets, such as hotels, are particularly susceptible to mold growth, which is a serious issue in Florida. The key to preventing mold growth is moisture control. Ambient humidity levels can be reduced by adjusting HVAC settings or employing a dehumidifier.

- Conduct periodic inspections for condensation, moisture, and signs of mold infestation and document problems.
- Respond rapidly to moisture problems before mold growth sets in by fixing leaks, keeping drip pans clean and flowing unobstructed, and venting or relocating moisture-generating appliances, such as dryers and dishwashers. If indications of conditions favorable to mold growth are encountered, clean and dry the damp spots within 24 – 48 hours of discovery. Materials, such as ceiling tiles, insulation, books, and paper items, which have suffered water damage, may need to be removed, discarded, and replaced. If ponded water is discovered, remove the water with an extraction vacuum. The drying process can be accelerated with portable fans. If porous flooring surfaces (linoleum, ceramic tile, vinyl, etc.) or treated wood surfaces are showing signs of moisture, wipe clean with mild detergent and dry. Be sure to check the sub-flooring for moisture as well. If wallboard is wet, it should be dried in place, if there is no obvious swelling and the

seams are intact. If not, it will have to be removed, discarded, and replaced. Wet paneling should be pried away from wall for drying. The wall cavity should be ventilated, if possible. Window drapes should be laundered or replaced. It is important to note, that even if materials are dried within 48 hours, mold growth may or may not have already occurred.
- Prevent moisture problems due to condensation by increasing surface temperature or reducing the moisture level in air (relative humidity). To increase surface temperatures, insulate. To reduce the moisture content, repair leaks and dehumidify (if outdoor air is warm and humid). Relative humidity should be no greater than 60% and ideally between 30 and 50%. If outside air is brought in and cooled without dehumidification, it will be at 90-100% RH, which is a problem (Cummings 2004).
- Provide detection/monitoring equipment such as relative humidity sensors.
- Provide employee training to deal with rapid response to spills, leaks, and other concerns impacting clean air. As with any human health threat, mold issues are no exception. Care should be taken to minimize exposure of mold spores to indoor air to limit the potential for spreading to other areas of the building. Workers should use appropriate protective equipment. Once mold takes hold, it is difficult to eradicate. Experienced environmental professionals such as professional engineers or certified industrial hygienist should be consulted if significant mold remediation work is required.
- As part of an integrated moisture prevention program, perform preventative maintenance activities, such as replacement of interior drywalls with paperless drywall products like DensArmor Plus, which can halt mold growth (Upton 2007).

Productivity

Besides the obvious health-related effects to poor indoor air quality, investigations have also shown that poor indoor air quality also impacts productivity, which is a parameter that has proven complicated to quantify. Some of the productivity performance measures that have been monitored include employee absenteeism, health care costs, sick leave days, turnover rates, and output per person (West 2005). Comparable measures for the hotel industry would include guest returns and survey responses. The weakness of causally linking a subjective productivity parameter to clean air indicators is that the confounding effects of factors such as worker motivation, level of competency, and pre-existing conditions also influence productivity and cannot be accounted for. Taken in context, overall results of worker productivity in relation to clean air practices show increases in output of 2 – 20% with a corresponding range of performance improvement on the order of 0.5 – 5.0% (Fisk 2000). Optimal performance is affected by comfort levels and sensory perception of indoor environmental quality factors such as those associated with clean air (i.e. odors, dust, etc.). The American Society of Interior Design found that 20% of workplace distractions were related to air quality issues (cited in West 2006). In any analysis of the productivity gains, the dollar value assigned is based on worker take home pay. West (2006) reported that salaries account for 84% of annual costs on a per square foot basis of a typical office building. Thus if productivity can be improved by 1 full hour per year, this can pay for the annual cost of lighting an entire office building, for example.

In Cambridge, MA the sick leave patterns among 3,720 employees of Polaroid collected in 1994 were analyzed with respect to indoor environmental quality (Milton et al. 2000). Consistent associations were found between increased sick leave with lower outdoor air supply (relative risk = 1.53) or complaints (relative risk = 1.52). A 50% decrease in sick leave time was found by adjusting the ventilation rate from 25 cfm to 50 cfm. The cost to increase the building ventilation rate to avoid the additional incremental risk of sick leave was calculated at $80 per employee per year. The cost of sick leave attributable to ventilation at current recommended rates was estimated as $480 per employee per year. These findings suggest a net savings of $400 per employee per year. On a national scale this could be as much as $22.8 billion per year in productivity savings. The results showed that the cost of providing additional ventilation for this large sample may be more than offset by the savings that result from reduced sick leave; however, the study was conducted in a major metropolitan city in the Northeast United States with a very different climate, lifestyle, diversity, and social factors.

During the Gulf War in 1991, 2598 servicemen were surveyed and seven barracks locations in Saudi Arabia were analyzed for a variety of pollutants. It was found that complaints of sore throat and cough were most closely associated with sleeping in air conditioned buildings. However, it was never resolved if the issue was infectious (due to overcrowding) rather than mechanical due to cooling without humidity control or the product of outdoor air pollutants related to particulate matter. Again, the very different conditions of Saudi Arabia when compared to Florida make extrapolations complicated.

Engineering Controls

At some point, generally all hotels will have some sort of minor construction projects or major renovations to the property to modernize, repair, or upgrade amenities and facilities. It is critical to consider clear air principles during these events to reduce indoor air quality problems resulting from the construction/renovation process and help sustain the comfort and well-being of construction workers, building occupants, and hotel guests. Implementing an Indoor Air Quality (IAQ) Management Plan for the construction and pre-occupancy phases of the building involves the following items:

- During construction meet or exceed the recommended Control Measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNCA) IAQ Guidelines for Occupied Buildings under Construction, 1995, Chapter 3.
- Protect stored on-site or installed absorptive materials from moisture damage.
- If permanently installed air handlers are used during construction, filtration media with a Minimum Efficiency Reporting Value (MERV) of 8 shall be used at each return air grille, as determined by ASHRAE 52.2-1999. Replace all filtration media immediately prior to occupancy.
- Sequence installation to avoid contamination of absorptive materials such as insulation, carpeting, ceiling tile, and gypsum wallboard.
- Seal HVAC system (cap ductwork) until construction is complete.
- Prior to occupancy, perform a system flush-out* or test the air contaminant levels in the building.
- Specify these items as a requirement of the construction management firm or subcontractor.

Flush-out. The system flush-out is designed to expel any dust and other abrasive materials that collected in the HVAC system and ductwork during construction. This is preferred in cases where occupancy is not required immediately upon substantial completion of construction. After construction ends, prior to occupancy and with all interior finishes installed, a system flush-out can be performed by supplying a total air volume of 14,000 ft^3 of outdoor air per ft^2 of floor area, while maintaining an internal temperature of at least 60°F and relative humidity no higher than

60% (USGBC 2005). Alternatively, if occupancy is desired prior to completion of the flush-out, the space may be occupied following delivery of a minimum of 3,500 ft^3 of outdoor air per ft^2 of floor area to the space.

Indoor Source Control. Another, often inevitable, source of contamination are pollutants generated inside the building itself. These contaminants are generally the product of building operation activities, such as storage or production of chemicals and other VOC sources. The solution to this form of contamination is to isolate the source from the occupants of the building and the outside environment. One of the ways to achieve this is to incorporate technologies to minimize and control pollutant entry into buildings and later cross-contamination of regularly occupied areas as follows:

- Entry points. Permanent entryway systems at least six feet long in the primary direction of travel to capture dirt and particulates from entering the building at all entryways that are directly connected to the outdoors. Entryway systems include: permanently installed grates, grilles, or slotted systems that allow for cleaning underneath, or roll-out mats that are maintained on a weekly basis by a contracted service organization. Entry mat systems are critical for trapping soil, pollutants, and moisture that otherwise would spread into and throughout the building, as well as in reducing the cost to properly maintain the building. The International Sanitary Supply Association reports that most of the dirt within a building is tracked in on people's shoes, and that 85% of this can be removed if entry mats are properly designed and maintained. Without an entry mat system, entrances and lobbies can quickly become unsightly, providing a poor first-impression about the maintenance and condition of the building. Dirt and pollutants can spread to larger areas; thereby requiring higher maintenance costs than otherwise would have been necessary, and increased grit tracked onto smooth-surface flooring can grind away the protective finish so that they quickly become loaded with pollutants. To effectively remove most pollutants from shoes requires a combination of mat materials, textures, and lengths. The combination may vary depending on the climate and location.
- Isolated exhaust systems for sensitive areas. Where hazardous gases or chemicals may be present or used (including maintenance bays and garages, housekeeping/laundry areas, storage areas, and copying/printing rooms), each space should be sufficiently exhausted to create a negative pressure with respect to adjacent spaces with the doors to the room closed. These spaces require self-closing doors and deck-to-deck partitions, or a hard lid ceiling. The minimum exhaust rate should be 0.50 cfm/ft^2, with no air recirculation. If using a centralized HVAC system, VAV control systems for individual rooms are recommended.
- Filtration/Air purification systems. In mechanically ventilated buildings, provide regularly occupied areas of the building with high efficiency air filtration media prior to occupancy that provides a Minimum Efficiency Reporting Value (MERV) of 13 or better. The HEPA filter is recommended for this purpose. Filtration should be applied to process both return and outside air that is to be delivered as supply air. Be certain that air handling units can accommodate required filter sizes and pressure drops. In terms of particulates, high efficiency filtration is only 40% efficient at removing particles that are less than 0.5 μm in diameter. Unfortunately, more than 98% of the particulate matter found in buildings is less than this size. Furthermore, it is precisely these very small particles that carry the bulk of the human health threat, and due to their small size, these particles remain suspended in the air for very prolonged

periods. For instance, a particle with diameter 0.01 μm has a sedimentation rate of 0.02 ft/d or a residence time of 51 days per foot (Newsome 2006).

- Other technologies that can be adapted include ionization, oxidizers, ultraviolet irradiation, or ozone.

Controllability of Thermal Comfort Systems. Individuals have widely varying ranges of thermal comfort. Hotels present many challenges from the perspective of dealing with the disparate needs of guest quarters, conference rooms, banquet halls, food preparation, laundry facilities, and swimming pools, to the difficulty of accommodating both smokers and non-smokers. To fully maximize the comfort levels of hotel guests and staff, individual controllability for thermal comfort, humidity levels (moisture control), and ventilation should be provided. To comply with ASHRAE 55-2004, separate thermal controls must be provided for 50% of the occupants based on air temperature, radiant temperature, air speed, or humidity. Therefore individual thermostats should be provided to maximize personal comfort. To monitor if thermal comfort levels are being maintained properly, the property owner should implement a thermal comfort survey of hotel guests and employees, shortly after renovations are complete (i.e. 6 months). Included in the survey instrument should be the overall satisfaction with the temperature and humidity and ventilation settings as well as real and perceived problems. If over 20% of guests indicate a problem, corrective measures should be developed and implemented.

Mold control. Contaminated HVAC systems are often incubation sites for biological contaminants (such as mold) and readily distribute spores and toxins to the rest of the building. Biological contaminants need high moisture levels, moderate temperatures, and a source of substrate for growth. Mold control is typically accomplished by controlling moisture and humidity. Many times, these conditions are at odds with energy efficiency measures. For instance, VAV systems with fixed outdoor air flow, high efficiency lighting (reduces temperatures and stimulates mold growth) and extreme temperature setbacks (too warm and too humid for unoccupied areas) can exacerbate mold issues. Conversely, some mold prevention measures will have the effect of increasing energy costs. For instance, raising outside air flow (brings in moisture), installing HEPA filtration (provides a san incubation site for uncontrolled growth and spread of mold), and reducing humidity levels with reheat systems will increase the electrical cost of HVAC service to the building (West 2005). Because the HVAC system can act an incubator for biological contaminants, it is important to keep the coil clean and free of infestation. This can be accomplished using a shortwave ultraviolet disinfection lamp or alternatively ozone systems are also available. Filtration systems should meet or exceed ASHRAE 52.2-1999, which for mold/spores indicates a minimum MERV rating of 8.

An important step in any indoor air quality implementation plan is to formulate a comprehensive and integrated approach. One such success story involves the Sheraton Rittenhouse Square Hotel in Philadelphia, PA, which switched over to using 100% organic cotton, dye-free linens and mattresses and chemical-free carpeting and paints, installing 25-foot tall palm trees that were specifically chosen for their 38% oxygenation rate, and pumping fresh, filtered air into guest rooms 24 hours per day (Hinton et al. 2004).

Comfort Levels

Indoor air quality can be thought of as a relative quality, depending on individual thermal comfort, microclimate preferences, and the flux of fresh outside air. Therefore, some of the most important factors affecting the quality of the indoor environment are temperature, relative humidity, and air velocity.

The following are some of the parameters recommended by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) for maintaining occupant comfort levels within buildings:

Temperature and Humidity. These two parameters relate directly to the occupant's perception of the indoor quality. Although humidity and temperature pose a health hazard only when their values are in the extremes, designers should strive to maintain both parameters at the optimal levels (ASHRAE Standard 62.1-2004):

- Summer: 73 – 79ºF (at 50% RH)
- Winter: 68.5 – 76 ºF (at 30% RH)

In Florida, it is not uncommon for relative humidity to reach 60 – 80% (FEES and Cook 1995). So maintaining the ideal levels listed above must be achieved through thoughtful design or by equipping the building with temperature and humidity sensors to monitor the environment and control the HVAC settings. Also, smaller individual rooms should be equipped with systems for manual control of the temperature conditions. In coastal environments, humidity will play an important role in indoor air quality.

Vibration and Noise. These parameters, which are a special concern in the design of factories, can produce dizziness and pain for the occupants. Vibrations and noises at certain frequencies (1-20 Hz, more than 120 dB) directly affect certain body organs, specially the eyes and hearing system, producing pain and, sometimes, permanent damage. When the sources of acoustical contamination cannot be avoided, special care should be taken to diminish their impact. The correct design of roofs and walls can lessen the effects of noise and vibration. Curiously, it has been found that offices where there are constant mild murmurs make workers more productive than those that are completely silent.

Outdoor Air Delivery (Ventilation). All buildings should strive to meet or exceed the minimum outdoor air ventilation rates set forth in ASHRAE 62.1-2004 Sections 4 – 7. The building tightness limit is based on 0.35 air changes per hour, but not less than 15 cfm of outdoor air per occupant. The recommended range is 15 – 60 cfm per person. More specific targets are listed for local exhaust fans installed in bathrooms, laundry, and kitchens.

For each space in the building, different criteria (policies, procedures and schedules) for ventilating buildings should be considered. Many factors will affect the ventilation intensity, frequency, and duration. These include functional issues, climate, indoor air conditions, and outdoor air conditions. Seasonal changes in air temperature, relative humidity, precipitation, solar intensity, and wind direction with respect to adjacent air pollution sources can have a considerable impact on ventilation needs.

A balance must be struck between the impacts of optimizing outside air ventilation on energy use and indoor air quality to provide an acceptable equilibrium between energy efficiency and occupant health. To accomplish this, provisions should be made to monitor the ventilation system with active performance feedback mechanisms to maintain minimum design ventilation requirements at all times. Said monitoring equipment should generate an alarm when conditions vary by 10% or more from the appropriate setpoint. Alarms can trigger a building automation system (BAS) alarm to the building operator or can trigger a visual or audible alert to the building occupants

Active control of ventilation can be accomplished using airflow tracking, differential pressure sensors, or carbon dioxide (CO_2) monitoring. For each mechanical ventilation system serving non-densely occupied spaces, a direct outdoor airflow measurement device capable of measuring the minimum outdoor airflow rate with an accuracy of plus or minus 15% of the design minimum outdoor air rate should be provided.

Carbon dioxide, which is a natural byproduct of metabolic respiration, is one of the most serious concerns in the field of Indoor Environmental Quality. Levels of CO_2 can be used to indicate the level of occupancy of a particular space. Because CO_2 is a colorless, odorless, and translucent gas, humans cannot sense if levels are too high or too low. However, commercially available carbon dioxide monitoring equipment utilizing dual infrared detectors can measure CO_2 levels from 0 – 3000 ppm. If CO_2 monitoring is conducted in an office for example, the measured CO_2 level can be set to automatically trigger a response if it violates a programmed range. Typical triggered responses would include automatically opening up the supply of additional outside air for ventilation purposes or simply triggering an audible alarm. Carbon dioxide monitoring equipment should be installed at the appropriate intervals (linear spacing and 3 – 6 ft above the floor) for areas with expected densities of 25 or more per 1000 ft^2. Outdoor background levels are 350 ppm CO_2 in the air (and rising due to climate change). ASHRAE 62-2004 recommends less than 1000 ppm CO_2 in the air, because human discomfort begins at levels above 800 – 1000 ppm. Long term health effects can be expected at sustained concentrations above 12,000 ppm CO_2 in the air.

As a rule of thumb, the exhaust outflow should be maintained at less than the outside air inflow. This helps to keep the outdoor contaminants out of the building. A minimum of 0.03 – 0.05 inches of water gauge (7 – 12 Pa) should be maintained in sensitive areas, depending on airtightness. Zone pressures can be modeled to specify the appropriate airflow between zones and perform balancing adjustments prior to and just after installation for design and operation, respectively. For mechanically vented spaces, the breathing zone outdoor air ventilation rates to all occupied spaces can be increased by at least 30% above the minimum rates required by ASHRAE Standard 62.1-2004 to enhance ventilation. However, this comes at a cost in Florida settings, and energy recovery ventilation systems may be necessary to make this feasible given the energy efficiency tradeoff. Additional ventilation will also increase summer moisture content, so that dehumidification will be required and enhanced mold control systems may be necessary as well. If we design to maintain positive pressure in the building, this will have the effect of increasing air quality and preventing mildew, particularly if the air is HEPA-filtered and dehumidified. In addition if the additional exhaust air is vented through the roof instead of doorways, warm moist air will be leaving the building in larger quantities. This will have the added benefit of increasing the HVAC system efficiency for cooling.

Use Low Emitting Materials. Volatile organic compounds (VOC) are gases emitted from certain solids or liquids. They include a variety of chemicals, some of which may have short and long term adverse effects on human health. Sources of VOCs include paints, sealants, adhesives, caulking, coatings, carpets, insulation materials, and many other common items found in hotels. One factor that makes VOCs a great source of concern is that their concentration indoors tends to be up to 10 times higher than the outside air concentrations (USEPA 2007). If air sampling is conducted, total VOC levels should not exceed 500 $\mu g/m^3$ (USGBC 2005).

Newer materials and furnishings present a higher health risk because VOCs are usually released at a decreasing rate as time passes. Thus, new construction and major renovations are particularly hazardous for inhabitants and builders. Care should be taken in selecting eco-friendly products for the finishes. Many sources are available for these products, and many options are readily and locally available. All adhesives and sealants used in the interior of the building (defined as inside of the weatherproofing system and applied on-site) shall comply with the requirements of the following reference standards:

- Adhesives, sealants and sealant primers should comply with the South Coast Air Quality Management District (SCAQMD) Rule #1168 VOC limits.

Table 3. VOC limits for adhesives, sealants, and primers as stated in SCAQMD Rule #1168 effective July 1, 2005.

Architectural Adhesives	VOC limit*	Specialty Applications	VOC limit*
Wood flooring	100	Sheet applied rubber lining	850
Structural glazing	100	Adhesive primer for plastic	550
Multipurpose	70	PVC welding	510
Ceramic tile	65	CPVC welding	490
Rubber flooring	60	ABS welding	325
Indoor carpet	50	Plastic cement welding	250
Carpet pad	50	Special purpose contact adhesive	250
Subfloor	50	Top and trim adhesive	250
VCT and asphalt	50	Structural wood member adhesive	140
Drywall and panels	50	Contact adhesive	80
Cove base	50		
Substrate Specific Applications	**VOC limit***	**Sealants**	**VOC limit***
Fiberglass	80	Single-ply roof membrane	450
Plastic foam	50	Nonmembrane roof	300
Porous material (except wood)	50	Architectural	250
Metal to metal	30	Roadway	250
Wood	30	Other	420
Sealant Primers	**VOC limit***		
Architectural porous	775		
Architectural nonporous	250		
Other	750		

*Units of g/L less water

- Aerosol adhesives should comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000, which specify a maximum of 70% VOCs by weight for special purpose aerosols.
- Paints and coatings used in the interior of the building should comply with the following criteria:
  1. Architectural paints, coatings and primers applied to interior walls and ceilings should not exceed the VOC content limits established in Green Seal Standard GS-11, Paints, First Edition, May 20, 1993. These are 50 g/L for flats and 150 g/L for non-flats.

2. Anti-corrosive and anti-rust paints applied to interior ferrous metal substrates should not exceed the VOC content limit of 250 g/L established in Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997.
3. Clear wood finishes, floor coatings, stains, and shellacs applied to interior elements should not exceed the VOC content limits established in South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect on January 1, 2004. These are 350 g/L (clear wood varnish), 550 g/L (clear wood lacquer), 100 g/L (floor coatings), 730 g/L (clear shellacs), 550 g/L (pigmented shellacs), 250 g/L (waterproof sealers and stains), 275 g/L (sanding sealers), and 200 g/L (all other sealers). Walls should be papered with water-based adhesives, whenever possible.

- Carpet installed in the building interior should comply with the testing and product requirements of the Carpet and Rug Institute (CRI) Green Label Plus program, which has emission criteria in micrograms per square meter per hour. Carpet adhesives should not exceed the VOC limit of 50 g/L. Carpet cushions should follow the CRI Green Label program.
- Natural wood products should only be used that have the Forest Stewardship Council (FSC) certification. Composite wood and agrifiber products as well as laminating adhesives used in the interior of the building should not contain any added urea-formaldehyde resins. Composite wood and agrifiber products include: particleboard, medium density fiberboard (MDF), plywood, wheatboard, strawboard, panel substrates and door cores.
- Within the specifications for any new construction or major renovation project, be sure not to specify any of the following items:
  1. Fiberwood or agrifiber flooring and wall coverings
  2. Preserved wood products that contain formaldehyde
  3. Rugs/flooring that contain a urea-formaldehyde
  4. Paints containing VOCs
- Ensure that VOC limits are clearly stated in each section of the design and construction specifications, where adhesives, sealants, and interior finishes are addressed.

Indoor air quality depends on many factors thermal comfort levels (acceptable temperature and relative humidity settings), control of airborne contaminants, and distribution of adequate ventilation air. Balancing indoor air quality with energy conservation requires deliberate care. Achieving thermal comfort begins with good design and continues with proper building management. The goal is to avoid uneven temperature gradients, radiant heat gains, or excessive losses (i.e. from windows), draftiness, stuffiness, excessive moisture, or high relative humidity (that can promote the growth of mold). Through careful selection of materials, designers can avoid introducing potential pollutant sources. Mechanical systems must be selected and installed with reliable ventilation systems that dilute contaminants and, to the greatest extent possible, supply fresh air on demand in the necessary quantities to the appropriate locations. Even if all clean air objectives are met, achieving an indoor air quality that is acceptable to all guests and staff may not be possible, owing to the diversity of sources and contaminants in indoor air as well as the tremendous differences in individual susceptibility and perceptions with regard to air quality.

Specific Areas

To make identification of best management practices less complex, measures will be subdivided into specific areas of the hotel. These are: main lobby/office, guest rooms/housekeeping, laundry facilities, kitchen/restaurant/bar, conference/meeting rooms, grounds (including landscaping, parking lot, recreational areas, mechanical systems, and operations and maintenance), and the swimming pool/spa areas.

Main Lobby/Office

-Energy-

Depending on the size of the hotel and its electricity demand, a small percentage savings can potentially translate to significant annual savings in the utility bill. Within the lobby of the hotel, several areas for improvements have been identified and are discussed in more detail below.

- **Building Envelope.** Standard heating/cooling losses, as well as solar heat gain, through the building envelope can substantially increase energy consumption. The shape, orientation, and color of the building can also impact the ambient temperature within the structure and its surrounding area. For example, if the building has a glass curtain wall that faces south, this will generate a significant added heat gain inside the building, causing the HVAC systems to work much harder to maintain the desired temperatures. During design a great deal of energy savings can be realized by altering the building orientation so that the curtain walls face north instead. The building structure should meet or exceed the building envelope requirements as found in Appendix B of the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard (ASHRAE 90.1-2004). Some examples of items covered in this standard are: double-pane-E glazing for windows, insulated walls and ceilings, and roof systems. To reduce energy losses through the building envelope, the following practices are recommended:

1. **Windows and doors.** Open doors and windows allow conditioned air to escape and outside air to enter. This requires additional energy to maintain comfortable temperatures. Windows and doors should be shut when not in use. Hotels may consider installing automatic door closing arms for bathrooms and guest room doors. Any cracks around operable windows, doors, openings, and through-the-wall or window type HVAC units should be sealed with caulk. In addition, damaged weather-stripping allows inside air to leak and outside air to enter. This requires additional energy to maintain comfortable temperatures. Door sweeps, weather-stripping, and gaskets on doors and windows should be inspected often and repaired if damaged. Finally, window replacement technologies should be evaluated because can decrease annual energy costs by up to 15% if properly installed by reducing losses and solar heat gain (FPL 2004). These systems can be used in new construction or window retrofits. Examples include: energy efficient windows, window treatments, or double-paned windows. Types of window treatments include, standard glazing, tinted glazing, reflective glazing, spectrally selective glazings, window films, and insulated glazing. Films reduce cooling loads, improve shatter resistance, block up to 99% of ultraviolet radiation, and reduce glare. The key parameter for windows is the Solar Heat Gain Coefficient

(SHGC), which measures how well a window blocks heat from sunlight. The SHGC is the fraction of the heat from the incident sunlight that enters through a window. The lower a window's SHGC value, the less solar heat it transmits. Another parameter is the Shading Coefficient (SC), which can be related back to the SHGC by multiplying by 0.87. It is recommended to install windows with SHGC < 0.40 or SC < 0.45 (Ohlsen 2007). Most standard windows are rated by the National Fenestration Rating Council (NFRC), which will have the SHGC value printed on the label. Additional parameters include the U-factor, which measures how well a product prevents heat from escaping, and the VT (visible light transmittance) value, which is an optical property that indicates the amount of visible light transmitted. A high VT is desirable to maximize daylight.

Energy Star® qualified windows, doors, and skylights are also available, which can save energy, increase the thermal comfort, and protect interior items from sun damage and fading. For windows, this is accomplished by the following technologies: 1) improved framing materials that reduce heat transfer and insulate better; 2) multiple pane systems that utilize a gas-filled space have a greater energy efficiency, increased impact resistance, and sound insulation; 3) low E (low emissive) glass uses special coatings to reflect infrared radiation that carries heat into the building and also reflects ultraviolet radiation to protect interior furnishings from fading; 4) gas fills using argon or krypton insulate better than air-filled spaces between panes; and 5) warm edge spacers keep the multiple panes apart by using advanced materials, which reduce heat flow and prevent condensation. For doors, energy savings are accomplished using multiple panes, tighter weather stripping, and energy efficient core materials. For skylights, the new energy-efficient technologies for windows also apply. In addition, tubular daylighting devices can also be used to transport sunlight into the core of the building or into closets, bathrooms, hallways, and other spaces without direct access to windows.

When planning a new construction or major renovation, consider orienting windows to the north to take advantage of indirect sunlight and using roof overhangs can help reduce solar heat gain by providing shade from the direct sunlight. Overhangs are much less effective against the lower angles of the east and west sun, therefore reducing the size and number or east and west facing windows can also help reduce energy use. Rather than using overhangs or louvers, strategically planting shade vegetation near the south, east, and west-facing windows will help reduce cooling requirements.

Rebates and tax credits for windows, doors, and skylights are available. The Energy Star® website[2] has a locator tool to help individuals and businesses earn up to $500 in federal tax credits (Energy Policy Act of 2005) and search for local rebates as well. These include sales tax exemptions or credits and rebate programs.

2. **Ceilings and Roof Systems**. Insulation reduces the heat flow through the building envelope. Ceiling insulation is a key factor in achieving thermal comfort levels within any building. To maximize energy efficiency, all gaps where air can leak in or out, including those around windows, doors, wiring holes, recessed lights, and plumbing vents must be sealed. Energy savings of up to 15 – 20% have been reported from installing guest room ceiling insulation or radiant barrier systems at a cost of $200 per room. This has a reported payback period on the order of one year (PA Consulting Group 2001). To maximize energy efficiency, the use of at minimum R-19 insulation in the walls and R-30 is preferred for ceilings. Appropriate insulation will reduce heating and cooling loads by making the building tighter, but there is a tradeoff, as tighter buildings will also trap indoor air contaminants.

---

[2] www.energystar.gov/index.cfm?fuseaction=rebate.rebate_locator

In terms of roof systems, green roof or cool roof technology may be effective. White or reflective roofing helps reflect heat and keep buildings cool. Cool Roof products are available as Energy Star® qualified based on ASTM E 903 with an incident solar reflectance (ICR) of 0.65 or greater (Burkett 2007). Cool roof materials have a high incident solar reflectance, or albedo, and a high thermal emittance, which is defined as the percentage of energy that a given material can radiate away after it is absorbed. Most cool roof applications for low-slope buildings have a smooth, bright white surface to reflect solar radiation, reduce heat transfer to the interior, and reduce air conditioning demand. On a typical summer day, traditional roofing materials may reach peak temperatures of up to 190°F (88°C). By comparison, cool roofs will not exceed temperatures of 120°F (49°C), reducing the heat gain by 37%.

Another alternative to traditional roofing is a vegetated rooftop garden or “green roof.” Unfortunately, in many parts of Florida, green roof technology must also include a rooftop irrigation system to keep the garden alive during the dry season, which could end up being a large seasonal water demand and a large energy demand for pumping that water up to the roof. Both systems help keep the roof material cooler and reduce the heat island effect.

- **Lights.** Lighting is a major energy demand in most hotels. According to Florida Power & Light Company (2004), interior lighting accounts for 19% (3.6 kWh/ft^2) and exterior lighting accounts for 4% (0.7 kWh/ft^2) of electricity usage in hotels and motels. Upgrading the lighting systems offers a high-return, low-risk investment. For instance, the Williams Inn in Williamstown, MA saved over 64,000 kWh in one year by installing more efficient lighting. The system cost $830 after utility rebates and saved the Inn $5776 in electricity bills over the first year. This amounted to a payback period of less than one month (USEPA 2004). To reduce energy losses from lighting, the following practices are recommended:

    1. **Minimize use of artificial light**. This is a pollution prevention concept. Using just enough light reduces the amount of energy consumed for lighting purposes. Hotels should consider eliminating or reducing external lighting not needed for safety or security. External lighting costs can be reduced by using photo-cells that detect ambient light or employing time clock controls that automatically turn off lights when not needed. Another technique for reducing lighting demand is to consider using natural daylight wherever possible. Using natural light will reduce lighting energy consumption; however, heat gain may occur in summer with open draperies and shades forcing the air conditioning systems to work harder. Lights in unoccupied areas should be turned off, whenever possible. Reminder placards for guests and staff to turn off lights when leaving a room can help get more compliance with this practice. Occupancy sensors can be used to detect the presence or absence of people for automatically turning lights on and off, accordingly. Occupancy sensors may reduce lighting energy consumption by 50% or more in some circumstances (Burkett 2007). They are used most effectively in spaces that are often unoccupied, including offices, warehouses, storerooms, restrooms, loading docks, corridors, stairwells, lounges, and conference rooms. Open-plan office spaces, where people may be moving in and out throughout the day, are not good candidates for occupancy sensors. Another technique is to use the lowest wattage lamp necessary to reduce energy requirements without sacrificing light intensity. Very often, spaces are overlit. Removing bulbs in pairs to reduce excessive lighting levels can be effective at reducing energy consumption while maintaining the desired lighting effect. Dimmer controls can also be installed in spaces such as meeting rooms and corridors. Dimmers control light output so that no more light than necessary is produced thereby reducing lighting energy consumption. Another option is to utilize light-colored walls and ceilings

because they act as reflective surfaces for artificial and natural lighting and can result in an increase of 15 – 50% in light intensity. Using natural light for daytime illumination will not only decrease the consumption of energy, but will also create a healthier indoor environment for the building's inhabitants. Another way of bringing the outside environment inside is by providing abundant views of the natural or urban landscape surrounding the building. The combination of daylight and views will create a sense of openness inside the building that may have subliminal effects such as inducing a sense of freedom, relaxation, and appreciation for the natural environment. According to the USEPA (2007), patients in hospitals designed with green building concepts such as daylight and views recover faster. Calculation of glazing factors or (alternatively) a physical measurement of indoor light intensity (every 10 ft spacing with a light meter) can be done by a hired professional to achieve maximum coverage of daylighting. Effects are maximized if at least 75% of the rooms in the building have daylight access and 90% have outside views (USGBC 2005).

2. **Use energy efficient lighting**. Maintenance is responsible for about 9% of total lighting costs to a hotel. Since lamp life is the main driving force for maintenance costs, installing longer-life lamps is a simple way to minimize maintenance dollars and reduce labor costs and operating expenses. Energy-efficient lighting solutions can reduce energy expenditures by up to 75%, simply by replacing outdated inefficient lamps. Many hotels have realized important decreases in energy consumption by merely replacing standard incandescent bulbs with energy-efficient compact fluorescent light bulbs. Less than 5% of energy used by incandescent lamps generates useful light. The remaining 95% is wasted as heat loss, which incidentally also increases air conditioning costs. High-efficiency compact fluorescent bulbs are 66% - 75% more efficient than comparable incandescents, last 8 - 20 times longer (> 15,000 hours), and do not emit lost energy in the form of heat, saving up to $30 per lamp annually or up to $82 over the life of the lamp (Sindoni 2006). Other efficient alternatives include: 1) halogen lamps, which last 2 – 4 times longer and are twice as efficient as incandescents, saving $25 over the life of the bulb, but they have high operating temperatures; 2) metal halide lamps, and 3) high-pressure sodium lamps, which generate a yellow light commonly used in parking lots and exterior walls, are 5 – 6 times as efficient as indandescents (APPA and ASBDC 2003). There are also directional lamps, dimmable lamps, and reflector lamps that offer intermediate savings and moderate color rendering index (CRI) improvements compared to conventional incadescents. Diffuse light is more expensive in terms of energy consumption, so focused light, from the use of task or spot lighting halogen lamps, is more efficient (APPA and ASBDC 2003). In 2004, FPL estimated that standard incandescent lamps made up 48% of the total lamp inventory in Florida hotels and fluorescent lamps accounted for 34%, while energy-efficient compact fluorescent lamps accounted for only 15% (FPL 2004). Clearly, there is much room for improvement.

   Another replacement program involves swapping out the conventional T12 lamps in favor of the energy-saving fluorescent T8 lamps, which are one-inch diameter compared to the T12 that are 1.5 inch in diameter. A typical fluorescent fixture with two T12 lamps uses 96 watts (Hinton et al. 2004), while a high-efficiency electronic ballast with two T8 lamps uses only 62 watts, representing a savings of 35% on energy consumption. Both systems generate the same amount of light, but the energy efficient T8 lamps produce much better color rendition. Newer 25 watt T8 lamps save up to 21% on energy and last 60% longer than standard 30 watt T8 lamps (Sindoni 2006). T5 lamps offer more power, increased light output (90 lumens per watt), and longer life. Electronic ballasts are available that achieve 90% efficiency in power transfer and saves 2 – 5 watts over standard instant start electronic ballasts. They use the lowest amount of power, while maintaining 100 Lumens per watt with the latest T8 lamps (Sindoni 2006).

Another opportunity to utilize energy efficient lighting is to replace standard incandescent exit signs with light-emitting diode (LED) exit signs. Energy Star® rated LED exit signs use up to 75% less energy and are estimated to last up to 220,000 hours. LED exit signs can operate with less than 5 watts, while conventional incandescent lamps require 40 watts per sign. Over a 10-year period, first costs, energy expenditures, and maintenance requirements for an incandescent sign will run around $380, while a comparable LED unit with a 10-year life would incur overall costs of about $65 (Hinton et al. 2004). According to the USEPA and Department of Energy, 100 million exit signs with incandescent lights are estimated to be in use in the United States. These consume 30 – 35 billion kWh per year. If all were switched to LED, electricity costs would be reduced by $75 million (USEPA and DOE 2007).

Approximately 40% of guests leave the bathroom nightlight on (E Source 2004), and research undertaken by WRA International (cited in www.pineapplehospitality.net) indicates that 16% of travelers actually bring their own nightlights with them on the road. LED night lights can be installed with motion sensors to reduce energy costs while improving guest safety. These will also eliminate the need to leave bathroom lights on throughout the night. Replacing four 100-watt halogen bathroom lamps at a Marriot and a Homes Suites Inn in Massachusetts with motion sensor nightlights demonstrated a payback period of less than one year for a system that is documented to last over 10 years. The newest LEDs have 50,000 hour life cycles (6 – 7 years of regular use) with 50 lumens per watt. Regular incandescent lamps have typically only 10-12 lumens per watt. One of the easiest energy-saving opportunities in guestroom lighting is eliminating the unnecessary extended operation of the bathroom fixtures. Energy Star® fixtures distribute light more efficiently and evenly than standard fixtures. They are readily available in decorative styles including portable fixtures, such as table, desk and floor lamps, and hard-wired options such as dining facilities, kitchen ceilings, under-cabinet lighting, hallway ceiling and walls, and bathroom vanity fixtures. Additional features can offer more energy savings, such as dimmers, automatic daylight shut-offs, and motion sensors for outdoor lighting. Finally, clean bulbs and lighting fixtures will generate more light intensity. Thus for maximum efficiency, remove dust from the surface of the light bulb.

- **Heating, Ventilation and Air Conditioning (HVAC).** Almost one quarter of the energy consumption in the commercial sector of the United States is used by the HVAC systems (EIA 2007). According to FPL (2004), about 50 – 60% of hotel energy usage is consumed by the HVAC system (10.8 kWh/ft^2) with direct-expansion (DX) units representing 65% of total cooling capacity and the remaining percentage from chiller systems. The following conservation measures will reduce HVAC energy consumption:

1. **Use shading**. To reduce solar heat gain through windows, shading is a cost-effective (pollution prevention) technique.
2. **Use natural light**. When cleaning guest rooms, the housekeeping staff should use natural daylight instead of artificial lighting. Conversely, draperies and shades should be kept closed in unoccupied rooms to reduce the heating effect of natural sunlight. This will reduce heat loss in winter and heat gain in summer.
3. **Set thermostats**. Temperature settings are recommended as follows: 78 – 85°F in cooling season; 65 – 55°F in heating season in unoccupied public spaces and vacant

rooms. Each degree of a higher temperature setting is equivalent to saving about 3% on cooling costs (APPA and ASBDC 2003). The “Auto” setting is preferred because it cycles the system on and off as needed, whereas the “On” setting keeps the fan continuously operating. To maximize efficiency, enclose and lock thermostats in public areas. Keeping staff and guests from tampering with thermostats will help control heating and cooling costs. However, lack of guest/employee control will adversely affect individual thermal comfort and productivity.

4. **Optimize HVAC usage**. Turn off heating and cooling in unoccupied guest rooms. This will help reduce costs without impacting the comfort of guests and staff. Connect bathroom fans to light switches to reduce excessive operation. Fans that operate continuously remove excessive amounts of heated or cooled air from guest rooms. Install timers on bathroom heat lamps so they turn off when not needed. This is more energy efficient than separate heating for bathrooms. (For hotels that use wall units for heat and air.) Keep windows and doors closed when not in use. Open doors and windows allow heated and cooled air to escape and outside air to enter, which requires more energy to keep building at desired temperature. Section off the hotel or motel so you can close down areas that are unoccupied during periods of low occupancy. One hotel in the Hilton Hotels Corporation was able to save almost $270,000 per year in energy costs after the installation of digital thermostats that monitor room occupancy and automatically adjust the temperature when occupants enter or exit a room (Hinton et al. 2004). Many commercial systems have economizers, which are arrangements of dampers, linkages, actuators, and controls that allow the use of outdoor air to achieve essentially free cooling without involving the use of the compressor. Economizers can lead to substantial energy savings in some climates (from 15 – 45%), particularly if equipped with rugged temperature, humidity, and CO_2 sensors (APPA and ASBDC 2003). Demand control ventilation systems limit the amount of outside air that needs to be conditioned (Burkett 2007), and variable air volume (VAV) systems control the amount of conditioned air supplied to each heating/cooling zone in the HVAC system.

5. **Install an Energy Management System**. An Energy Management System (EMS) is a program that allows operators to monitor the building’s energy load. The most common use is monitoring the HVAC. An EMS usually includes a computer, an energy management software program, sensors and controls, and in larger systems, a communications network. An energy management system can save 10% to 40% on electric bills. Consider benchmarking and building commissioning to provide a basis of comparison for energy savings. Commissioning is a process in which engineers observe a building and make adjustments to ensure that systems are operating appropriately and efficiently. Commissioning typically occurs when a facility first opens, but re-commissioning periodically can also be beneficial. For a typical 100,000 ft^2 hotel, re-commissioning can achieve about $13,000 (10 – 15% of annual energy bills) in savings per year, from resetting existing controls to reduce HVAC waste while maintaining or even increasing comfort levels for occupants. Commissioning can be costly, however, with professional services estimated at about 5 – 40 cents/ft^2. State of the art, energy management systems are relatively easy to install in new construction. Older properties can be retrofit with off-the-shelf technologies available from some of the Florida Green Lodging Vendor Partners. However, hotels that share indoor areas with retail or merchandising or dining facilities that are operated through leasing or subcontracting can be more complicated.

6. **Perform scheduled maintenance**. Conducting scheduled maintenance on the HVAC system will increase performance and decrease energy use. Clean condenser and

evaporator coils. A very thin layer of dust reduces efficiency. Make this a part of the preventative maintenance schedule. Cleaning of the HVAC system is recommended every six months. This can be accomplished most effectively for packaged systems with steam cleaning techniques. Filters should be checked and cleaned regularly each month, particularly during times of heavy use or high occupancy. This will help improve efficiency by decreasing the resistance to airflow, so that the system does not have to work as hard (i.e. using less energy) to maintain the set temperature. A clean filter will also prevent dust and dirt from building up in the system, leading to accelerated maintenance issues or premature system failure. Leaks in the equipment and ducting should be sealed to reduce energy loss. Researchers at the Department of Energy's Lawrence Berkeley National Laboratory have developed an aerosol-based product called MASIS ("mobile aerosol-sealant injection system") for sealing the ducts of large commercial buildings.

7. **HVAC component replacement**. HVAC systems should be designed to reflect the building's use, occupancy patterns, density, passive solar opportunities, office equipment, lighting levels, comfort ranges, and space-specific needs (Siegelbaum 2005). If the HVAC system is under-performing it may be necessary to consider replacing some or all of the essential elements. Some examples include electric variable speed air conditioning, electronic adjustable-speed drives, and upgrading chillers, dehumidifiers, refrigerants, fans, and boilers to Energy Star® systems. Another technology to consider is an energy recovery ventilation (ERV) system. ERVs reduce the costs of cooling outside air by transferring energy from the conditioned inside air to cool the warmer outside supply air, thereby reducing the temperature differential that the HVAC system has to battle against. The most efficient ERV units meet the ARI 1060 rating with a winter effectiveness that exceeds 65% (Burkett 2007).

   Two basic types of HVAC designs include chillers, which produce cold water that runs through cooling coils as air is passed over them, and direct expansion (DX) systems, which compress refrigerants through an expansion valve to generate a cold refrigerant in the cooling coil. Older reciprocating chillers can be replaced with new energy-efficient models (0.78-0.85 kW/ton) or with centrifugal chillers (0.56-0.70 kW/ton). Design the chiller sizing based on the actual the cooling load. If replacing an existing chiller, consider downsizing it. Apart from wasting enormous amounts of energy, oversized HVAC equipment contribute to mold and mildew in guest rooms (E Source 2004). Centrifugal chillers are better for large constant loads, while reciprocating chillers are more efficient for variable loads. Auxiliary condensers to preheat makeup water for centrifugal chillers will pay for themselves in under a year. Chillers equipped with variable-speed drives can be cost-effective energy savers, but are not recommended for humid climates. Cooling towers can also be optimized. Improperly maintained cooling towers produce warmer cooling water resulting in condenser temperatures that are 5 – 10°F higher than necessary. For each degree increase in condenser temperature, the chiller will consume 2.5 – 3.5% more energy ("Development of Criteria and Benchmarks for Green Hotels in Thailand- Phase I. Oregon Economic and Community Development Department" 2002, cited in Siegelbaum 2005). Using variable speed drive motors allow HVAC systems to automatically adjust efficiency to actual loading by changing the speed of the AC motors continuously to match the energy demand. Alternatively, desiccant cooling and dehumidification systems (below) offer a variety of benefits: They can operate on natural gas, reducing peak electric demand, and they help to avoid costly mold and mildew damage.

Dehumidifiers. These systems employ desiccant cooling and dehumidification to absorb water and release it again when heated. Desiccants can provide dehumidification and can also extend the application of evaporative coolers into more humid climates. A 40-pint Energy Star® qualified dehumidifier can save consumers roughly $20 per year. This can add up to $200 or more over the life of the unit, enough to pay for the dehumidifier. The energy efficiency of dehumidifiers is measured by its energy factor, in L/kWh. In general, a higher energy factor means a more efficient dehumidifier. As of March 2007, there are 97 models of Energy Star® rated commercial dehumidifiers with energy factors ranging from 1.21 – 2.75 L/kWh. The energy savings is primarily achieved through more efficient refrigeration coils, compressors, and fans compared to conventional models, which means they use less energy to remove the moisture. Energy Star® rated models remove the same amount of moisture as a similarly-sized standard unit, but use 10 – 20% less energy. Dehumidifier capacity is typically measured in pints per day and is determined by two factors: 1) the size of the space that needs to be dehumidified, and 2) the conditions that exist in the space before dehumidification. Use the chart below to estimate the capacity.

Table 4. Dehumidifier capacity estimation.

Condition Without Dehumidification	Area (ft^2)				
	500	1000	1500	2000	2500
Moderately Damp (space feels damp; musty odor only in humid weather)	10	14	18	22	26
Very Damp (space feels damp; musty odor; damp spots on walls and floor)	12	17	22	27	32
Wet (space feels and smells wet; walls/floors sweat; seepage is present)	14	20	26	32	38
Extremely Wet (laundry drying, wet floor, high load conditions.)	16	23	30	37	44

Relative humidity (RH) is the amount of water vapor actually present in the air compared to the water vapor saturation level at the desired temperature. The optimum RH level for a building is generally considered to be between 30% and 50%. Anything above this range may promote bacteria or mold growth. During the heating season, humidity levels should be in the range of 30% to 40% RH to prevent window condensation. Many dehumidifiers include a built-in humidistat, which is a device that allows the user to set the desired RH level. Once the room reaches the desired RH level, the dehumidifier will cycle on and off automatically to maintain the level. If the dehumidifier does not have a built-in humidistat, or has a humidistat that does not show RH levels, a hygrometer (a gauge that measures relative humidity) is required to measure RH levels and enable the user to monitor when to turn the dehumidifier on and off.

Most dehumidifiers use a removable plastic bucket and warning lights to indicate when the bucket is full and needs to be emptied. There is typically an automatic shutoff when the bucket is full, so overflows are not possible. If the dehumidifier unit relies on a built-in condensate pump to remove the water collected, disconnect the pump, attach a hose to the drain fitting, and connect it to a nearby floor drain to allow for gravity drainage instead of using unnecessary energy to dispose of the water. Most dehumidifiers have top-mounted air discharge and can be placed against walls. Otherwise, make certain that the unit is located away from walls and furniture, so that air can circulate freely around the unit. Locate the equipment away from sources of dust and dirt, which can clog coils and grills. Frost can form on the condensing coils if the air temperature drops below 65 degrees, and may negatively affect the performance of the product by causing the compressor to cycle on and off repeatedly without removing moisture from the air. If this happens, the unit should be switched off and allowed to defrost before it is turned back on. Some dehumidifiers come with an antifrost sensor, which will automatically turn the unit off if the air temperature drops below a certain point.

To minimize the amount of water collected, external doors and windows to the space being dehumidified should be closed while the unit is running. This will ensure that the space is dehumidified as efficiently as possible. As a dehumidifier removes moisture from the air, it slightly warms the space around it. So do not locate units near thermostats or air conditioning equipment because the temperature differential will trick the HVAC system into working more than it should for cooling purposes.

Ceiling fans. Hotels should consider using ceiling fans in public areas. Ceiling fans can reduce cooling costs because they use only 15% of the energy consumed by a typical air conditioning unit. Energy Star® rated ceiling fan/light combination units are about 50% more efficient than conventional units. This represents a $15 – $20 per year savings on utility bills, plus any additional air conditioning savings gained when the fan is operated properly. For a $150 ceiling fan purchase with install, the payback period is on the order of 3 months (PA Consulting Group 2001). These savings can be maximized through optimizing the ceiling fan installation and usage. Efficient operation of ceiling fans involves proper anchoring to a ceiling joist and proper balancing of the blades. Any wobbling due to misalignment or inadequate mounting will cause friction losses, which will reduce the operating efficiency of the motor and result in higher electric bills. It goes without saying that the fans should be turned off when the room is not occupied, but if the fan must be used continuously, set the unit to rotate counter-clockwise to induce downdraft "wind-chill" effect. If ceiling fans are in use, the thermostat should be reset to compensate.

Boilers. As of March 2007, there are 340 models commercially available that meet the Energy Star® qualifications, which means that these units have an annual fuel utilization efficiency (AFUE) rating of 85% or greater. Direct-vent, sealed combustion condensing water heaters and boilers are highly efficient. The efficiency gains are largely the result of the following features:

1. Electric ignition, which eliminates the need to have a pilot light burning continuously.
2. New combustion technologies that extract more heat from the same amount of fuel.
3. Sealed combustion chambers that use outside air to fuel the burner, thereby reducing draft and improving safety.

- **Water Heating.** A 1994 survey of Florida hotels and motels showed that water heating (including swimming pools) is the largest single user at 38.5% of the total annual energy use (Miller 1994). The combined cost of water and wastewater services is typically on the order of $5-6 per thousand gallons (Helfritch 2006). If the cost of energy to heat and pump water is factored in, the cost can be as high as $9 per thousand gallons. In addition to water use reduction, the following energy conservation measures are also recommended:

  1. **Minimize the amount of hot water needed**. Operate laundry and dishwashing equipment with full loads only. Processing partial loads will not only waste hot water but also the energy used to heat that water. Low-flow showerheads and fixtures will also reduce the volume of hot water needed. An aggressive leak control program should be

pursued. A hot water faucet dripping at a rate of 1 gallon per hour will $30 – $120 in energy (Hinton et al. 2004). If hot water use exceeds 100 gpd, you should consider switching to gas service or replacing the electric water heater with a heat pump water heater (APPA and ASBDC 2003). This will potentially cut electrical costs in half, and, if the unit is located in a hot spot like a kitchen, it will provide free cooling as a bonus.

2. **Lower water temperatures**. Reduce water temperature for hand washing to 110°F from 140°F. The Florida Energy Extension Service recommends reducing domestic hot water temperatures to 110 – 120°F at the water heater. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends that temperatures for showers be limited to 110°F. For laundry applications the maximum limit is 160°F (depending on local health code requirements), and for dishwashing, the limit is 180°F, keeping in mind that some models have booster heaters incorporated into the mechanism. Each degree downward can be expected to generate $1 savings annually (APPA and ASBDC 2003).

3. **Insulate hot water heater tanks**. Except for reducing the amount of hot water used, tank insulation may be the best energy conservation opportunity. Insulation kits cost as little as $10 – $20 and will pay for themselves in energy savings in 12 months or less. Insulate hot water pipes. In a system with about 200 feet of piping, good insulation will save approximately $15 – $25 per year. Hot water pipes should be insulated to lock in the heat and minimize losses.

4. **Replace inefficient water heating systems**. High efficiency equipment may be more expensive than average efficiency units, but the higher initial capital outlay can be recovered through increased energy savings. For instance, tank-less water heaters can save energy by eliminating the standby energy losses suffered by tank water heaters. Drain water heat recovery systems can also save energy by using the heat in drains to preheat water coming into the water heater via heat exchange. In general, installing multiple, smaller water heaters (closer to the user) provides better reliability, effectiveness, and efficiency compared to using one large centralized hot water heater unit.

- **Management Practices**. A variety of simple measures can be employed for the front office, lobby, or back of the house areas to gain additional energy savings.

1. **Minimize operation of office equipment**. Office equipment that continuously runs consumes a significant amount of energy in aggregate. Systems should be unplugged when rooms or offices are unoccupied for extended periods. If the machine is equipped with energy saving software or features, be sure to enable those systems. For instance, computers and monitors automatically power down to 30 watts when not in use, and printers power down to 10 – 100 watts, producing less heat, reducing air-conditioning costs, and contributing to a more comfortable work space (APPA and ASBDC 2003).

2. **Equipment replacement**. Purchasing Energy Star® equipment, which includes built-in power management features that switch to a low-energy mode when not in use, reduces energy consumption and provides additional savings in air conditioning (from excess heat generation) and wear-and-tear. When not in use, be sure to activate the stand-by mode or “sleep” function settings on Energy Star® labeled electronics. For example, an Energy Star® computer, in sleep mode, uses 70% less electricity than computers without power management features. USEPA offers Powerdown Software that decreases CPU power consumption on most computers, while still running. Energy

Star® office equipment not only includes computers, but also printers, copiers, fax machines, commercial and industrial transformers, water coolers, television sets, monitors, VCRs, and other items commonly found in hotels. Energy Star® printers can cut printing-related electricity by 65% or more, particularly if multiple users are networked to a central printer. As an example of savings, fax machines that have earned the Energy Star® rating can reduce energy costs by almost 40% (APPA and ASBDC 2003).

3. **Install Energy Control Systems**. that allow management central control of individual rooms. During periods of low occupancy, close down entire wings or floors and reduce lighting and HVAC systems in these areas. Assign guests to adjoining rooms to allow the heating and cooling of occupied rooms to act as a buffer or insulator. A programmable thermostat program helps ensure that unoccupied rooms revert back to a predetermined temperature. Some include a motion sensor to determine if the room is occupied. Sensor lightings, timers, motion detectors, and key activated systems are commercially available. Occupancy sensors detect people in a room and automatically turn lights on and off. These sensors cost between $25 and $80 and are an excellent option for spaces that may be unoccupied for portions of the day. Consider installing occupancy sensors in private offices, conference rooms, restrooms, and storage areas. Table 5 shows data from a California Energy Commission/U.S. Department of Energy, Electric Power Research Institute study which determined the maximum energy savings potential under optimized conditions (cited in APPA and ASBDC 2003).

Table 5. Energy savings potential in spaces with occupancy sensors.

Application	Energy Savings
Private Office	25 – 50%
Open Office Space	20 – 25%
Restrooms	30 – 75%
Corridors	30 – 40%
Storage	45 – 65%
Meeting Rooms	45 – 65%
Warehouse	50 – 75%

Pineapple Hospitality piloted programmable in-room digital thermostats at a 132-room Holiday Inn Express in Arkansas. The systems last up to 10 years and cost $100 to install. In the test case scenario, they paid for themselves in 3 – 12 months with 25% energy savings. In the test case, before installation, each block of six guestrooms was tied into a compressor with no control system. Thus it was possible to have four guestrooms placing high temperature demands on a compressor and two others requesting cold climates at the same time, causing the compressor to malfunction. With a programmable thermostat, the operations staff locked in temperature limits of 72 – 74°F in the summer and 66 – 68°F in winter and eliminated compressor shutdowns (Burger 2005).

Programmable units are now available with concealed temperature set points, peak set points, mold/mildew controls, and keyboard lockouts for public areas. Some systems come with a lanai switch input, which allows the unit to shut-off the A/C when the external screen door is ajar, and others come equipped with an electroluminescent display that doubles as a nightlight.

4. **Implement a Preventative Maintenance Plan**. It is cost effective to establish and perform regularly scheduled preventive maintenance for all of the property's major appliances. This plan should include annual tune-ups, filter replacement, leak checks, and cleaning.
5. **Booking Practices**. Registration staff can help save energy costs by booking rooms in clusters, so that only occupied building areas or wings need to be maintained at guest comfort levels. Rooms located on top floors, at building corners, and along south-facing walls will be the most energy-intensive. These rooms should be booked only when absolutely necessary (E Source 2004).

-Clean Air-

In terms of clean air practices, the main lobby and the office sections of the property offer many opportunities for improving the quality of the indoor environment. In addition, the main lobby and the back of the house office spaces are great places to introduce employees, guests, and visitors to the commitment to clean indoor air by posting highly visible signs and placards in these high-traffic areas. Some more specific ways to improve indoor air quality include:

- **Environmental Tobacco Smoke Control**. Both the back of the house facilities and the main lobby should be free from smoking in order to control tobacco smoke and associated contaminants, preventing non-smokers from being subject to exposure. The most effective way of doing this, is to prohibit smoking. Florida State Law (Florida Clean Air Act of 2003), prohibits smoking in the workplace, which effectively takes care of the offices and main lobby, although the law allows smoking in designated rooms at motels and hotels and stand alone bars with no more than 10% of revenue from food sales. However, it is still likely that hotel employees as well as guests will contain a percentage of smokers because approximately 1 in 5 of the American population smokes (Rosenwald 2006). Therefore, it is critical when smoking cannot be avoided, that special areas should be designated to isolate smokers from the general building. Exterior designated smoking areas should be located at least 25 feet away from entryways, outdoor air intakes, and operable windows. These areas should not be located in or near to major access/egress points, alcoves, lobby entrances, or breezeways. In addition, designated smoking areas should not be located near HVAC equipment, air handlers, or ventilation air distribution systems to safeguard nonsmokers and children from the damaging effects of secondhand smoke exposure.

  If the designated smoking areas are located indoors, make sure that the room is designed to effectively contain, capture and remove ETS rapidly and completely from the building. At a minimum, the smoking room must be directly exhausted to the outdoors with no re-circulation of ETS-containing air to the non-smoking areas of the building, and enclosed with impermeable deck-to-deck partitions. With the doors to the smoking room closed, the exhaust system should operate sufficiently to create a negative pressure of 1 – 5 Pa (0.004 – 0.020 inches of water gauge) (USGBC 2005). Differential air pressure performance of the smoking room shall be verified by conducting 15 minutes of measurement, with a minimum of one measurement every 10 seconds, of the differential pressure in the smoking room with respect to each adjacent area and in each adjacent vertical chase with the doors to the smoking room closed. The testing will be conducted with each space configured for worst case conditions of transport of air from the smoking rooms to adjacent spaces with the smoking rooms' doors closed to the adjacent spaces.

Uncontrolled pathways for ETS transfer between building spaces should be minimized by sealing penetrations in walls, ceilings and floors, and by sealing vertical chases. All doors in the leading to common hallways shall be weather-stripped to minimize air leakage into a hallway with access to a designated smoking area Acceptable sealing shall be demonstrated by a blower door test conducted in accordance with ANSI/ASTM-E779-03, Standard Test Method for Determining Air Leakage Rate By Fan Pressurization, and the use of the progressive sampling methodology defined in Chapter 4 (Compliance Through Quality Construction) of the Residential Manual for Compliance with California's 2001 Energy Efficiency Standards (www.energy.ca.gov/title24/residential_manual). Compliance should demonstrate less than 1.25 square inches leakage area per 100 square feet of enclosure area (i.e. sum of all wall, ceiling and floor areas). These practices will have the added extra benefit of reducing energy demand by increasing the building tightness.

Hotel staff should be aware that odors from designated smoking areas can be transferred to other areas of the building by housekeeping (i.e. smoke-impregnated furniture, linens, draperies, window treatments, etc.). Care should be taken to completely clean these items before moving them around in sensitive areas of the hotels such as the outside air intakes, lobbies, elevators, etc.

Finally, some hotels have completely prohibited smoking altogether. For instance, Westin Hotels, which is owned by Starwood Hotels and Resorts Worldwide Inc., banned smoking in 77 of its properties in 2005. Then Marriott International Inc., the nation's largest hotel chain, followed suit and banned smoking in all of its 400,000 hotel rooms in the United States and Canada the following year. Twenty years ago, about 50% of rooms were set aside for smokers, but now only 5% of guests are requesting smoking rooms (Rosenwald 2006).

- **Cleaning Products**. The housekeeping staff should be using "environmentally friendly" products whenever feasible. Generally, plant-derived botanicals or eco-friendly cleaners that contain no synthetic organic compounds, no petroleum-based products, and no chlorine are preferable. Many of these products are commercially available or can be homemade, such as vinegar as a local disinfectant instead of chlorine.

    1. Toilet cleaners typically contain chlorinated phenols, which are toxic and potentially carcinogenic to the respiratory and circulatory systems.
    2. Window cleaners typically contain diethylene glycol or butoxyethanol, which can depress the central nervous system.
    3. Spray and wick deodorizers typically contain formaldehyde, which is a respiratory irritant and a suspected carcinogen.
    4. Floor cleaners and degreasing agents typically contain petroleum solvents, which damage mucous membranes and lead to acute respiratory problems.
    5. Floor strippers often contain ammonium hydroxide, ethanolamine, and butoxyethanol, making this product one of the most dangerous handled by housekeeping staff (Barron et al. 1999).
    6. Acidic porcelain cleaners are used for removing hard water deposits (scale) and other stubborn stains. They are formulated with hydrochloric, phosphoric, or hydroxyacetic acid and are corrosive and potentially dangerous for skin burns and lung irritation.

7. Metal polishing agents typically contain tetrachloroethylene or volatile organic compounds, which are potentially carcinogenic.
8. Carpet shampoo typically contains nitrilotriacetic acid and carpet spot removers contain tetrachloroethylene (Barron et al. 1999). These substances are likely carcinogenic.
9. Furniture restoration products may contain tri-butyl tin or formaldehyde, which are toxic and potentially carcinogenic (Barron et al. 1999).
10. All-purpose spray cleaners typically contain alkyl phenyl ethoxylates, ethanolamine, or butyl cellosolve, which damages the central nervous system and attacks bone marrow, kidneys, and the liver.

It is likely that housekeeping and management staff are not aware of the chemical composition of cleaning products. Therefore, material safety data sheets (MSDS) should be posted and read carefully before selecting cleaning agents to help choose the most safe and environmentally friendly products available. Green Seal is an independent, non-profit organization that evaluates and lists environmentally responsible products and services. Since 1995, Green Seal has partnered with the lodging industry to promote environmentally responsible products and practices within lodging properties. The average hotel purchases more cleaning products in one week than one hundred families typically do in one year (www.greenseal.org). Furthermore, both hotel guests and staff may be exposed to many environmental toxins from products ranging from cleaners to paint to floor coverings. These all represent opportunities to reduce impact and improve sustainability. Certainly, Green Seal is not the only list available for eco-friendly purchasing. Regardless of the certification or manufacturer claims, the substituted cleaning product must have the following characteristics:

1. Biodegradable
2. Contain no known carcinogens, endocrine disruptors, or reproductive toxins
3. Contain no alkylphenol ethoxylates
4. Contain no dibutyl phthalates
5. Contain no heavy metals
6. Contain no ozone-depleting compounds
7. Contain no optical brighteners (fluorescent whitening agents)
8. Contain low VOCs
9. Contain no aquatic toxicity

Even if eco-friendly cleaners are used or not, it is still critical to insure that work areas are well-ventilated (to the outside) using either permanent building ventilation specifically designed for this purpose or using properly sized portable fans. Manufacturer's label instructions should be followed carefully, and the appropriate amount of material should be optimized for the specific purpose by incrementally adjusting product usage until maximum efficiency is achieved with the minimum amount of chemical to get the job done.

If chemicals are spilled, they should be cleaned up immediately so that the excess material does not soak in or becomes entrapped in the ventilation system. Also it is important to make certain that excess material does not runoff into the storm sewer system accidentally.

Make the extra effort to instruct sub-contractors, pest control personnel, and housekeeping staff to observe clean indoor air policies, and post notices for guests when chemicals are in use. If notified of the appropriate reason and timeframe, guest complaints can be reduced to a minimum.

- **Idling**. Many hotels operate a shuttle bus service, valet parking service, or heavy maintenance vehicles. With these amenities, it is likely that vehicle idling will become an issue, particularly in a high traffic area, such as the entranceway to the main lobby, for example. Excessive idling produces highly concentrated vehicle exhaust emissions. These are certainly not desirable, particularly near the lobby and loading areas. Signboards can be used to encourage drivers to turn off their engines when stopping for extended periods (i.e. $t > 30$ seconds – 5 minutes). Contrary to popular belief, prolonged idling is unhealthy for engines. Actually starting and stopping the engine is more cost-effective than prolonged idling. Consideration should be given to replacing maintenance vehicles with electric powered golf carts or alternative fuel vehicles (including bicycle power). For shuttle bus service, pollution prevention techniques can be employed to optimize the number of person-trips required. Thus only a minimum number of buses will be in operation, lowering emissions. For valet service, locating the waiting area more than 25 feet from the lobby entrance and providing ample natural ventilation will help to minimize impacts.

- **Building Materials**. For the building itself, the materials used in construction can contribute to the degradation of indoor air quality. One major item for older hotels can be asbestos, which is a group of impure magnesium silicate mineral fibers commonly used for insulation (found in vermiculite) and as a fire-retardant, acoustic insulator, thermal insulation, fire proofing, and in components of other building materials. Although the material is banned by USEPA, asbestos is still commonly found in older homes (prior to 1980), in pipe and furnace insulation materials, asbestos shingles, millboard, textured paints, ceiling treatments, plaster (DuChene 2005) and other coating materials, and floor tiles (USEPA 1990). Elevated concentrations of airborne asbestos can occur after asbestos-containing materials are disturbed by remodeling activities. Asbestos containing materials can also become damaged over time and release fibers into building air. Breathing in air containing asbestos fibers can lead to lung disease, cancer of the respiratory system, chest, or abdomen (mesothelioma), or asbestosis, which is an irreversible lung scarring that can be fatal. Smokers are at higher risk of developing asbestos-induced lung cancer.

  If asbestos is suspected within the building, consider scheduling a building inspection and asbestos assessment with a qualified inspector able to perform the sampling evaluation and laboratory analysis of the suspect material. If asbestos is discovered in the building, the first step is to inform building maintenance personnel where the material is located and to avoid disturbing those areas. A visual inspection combined with continuous monitoring of its condition should be arranged. Follow up inspections should help to make certain that any asbestos damage or release will be detected and corrective action will be undertaken immediately. Air monitoring to detect airborne asbestos fibers may prove useful. All of the building asbestos-related management reports, policies, respirator use procedures and logs, fiber release reports and inspection logs should be stored in permanent files. Finally if asbestos management is not providing the desired results, it may be necessary to consider removing the material. This should be conducted by properly trained and licensed sub-contractors.

  Other building materials that fall under this category include emissions from new furnishings and floorings, damp carpeting or gypsum wallboard (which fosters mold growth), ceiling materials, VOCs from glues and sealants, cabinetry or furniture containing pressed wood products made with formaldehyde, items that are painted or coated, or carpets and fabrics with styrene butadiene rubber (SBR) latex backing material that contain 4-Phenylcyclohexene (4-PCH). These items should be avoided whenever possible or vented to the outside to avoid accumulation of high concentrations of pollutants within a relatively small physical space. In extreme cases, some of these items can be replaced with less harmful materials such as floor bamboo or marmoleum products.

- **Management Practices**. A variety of simple measures can be employed for the front office, lobby, or back of the house areas to help establish clean air practices throughout the property:

    1. **Increase Awareness**. Clean air practices should be a consideration during budgeting and planning periodic upgrades, repairs, and renovations to the guest facilities as well as selection of sub-contractors such as the pest control service and lawn service. Be sure to involve employees and guests in campaigns to increase awareness, and engage them in helping to achieve clean air objectives. This should also enhance public relations and perception of the property as a caring, clean, and environmentally-friendly facility.
    2. **Provide Training**. Educational materials for all hotel personnel, housekeeping staff, security, management, and guests can be provided to highlight the importance of clean air practices. This way, all staff will be familiar with, and able to recognize, critical air quality issues such as leaks and fugitive exhaust emissions. This will help reduce response time and eventually, guest complaints by identifying and addressing smaller concerns before they become much larger and more costly to repair. These training opportunities should include discussions on clean air policies and contingency procedures for reporting and addressing air quality concerns. It is also extremely important to discuss how to explain air quality activities to guests and how to handle air quality complaints and inquiries.
    3. **Monitoring**. Staff should document air quality monitoring data using maintenance logs (i.e. filter cleaning/replacement, HVAC/ductwork cleaning, and routine status checks), chemical usage logs, and air quality monitoring charts that provide information regarding trends, level of service needed and compliance with scheduled activities, and corrective measures in response to guest/staff complaints. This will reduce costs and response times. Over time, a record of where and when clean air practices problems occur can be a valuable tool for management in deciding how to allocate limited resources to address these concerns (Hinton et al. 2004). Track Comments and complaints should be tracked to monitor performance of corrective action.
    4. **Conduct Periodic Clear Air Inspections**. A preventative maintenance approach to clean air practices upgrades will help prevent more expensive remediation actions in the future and reduce liability stemming from air quality issues (Hinton et al. 2004). Indoor Air Security Checks (I-ASCs) will help make certain that staff and guests have not left vents and openings, such as doors, windows, access panels, and entranceways in the wrong positions and that temporary seals and enclosures (plastic sheeting, etc.) are in place and properly secured. Areas that are particularly susceptible to contamination should be regularly inspected, cleaned, repaired, or replaced. Items such as older rugs, carpets, floor coverings, mattresses, and bedding which may have become contaminated, damaged, or otherwise defective

due to old age and/or disrepair should be targeted for removal on a periodic basis. The HVAC system is also one of these components. For example, the ducting network may be leaking and contributing to the spread of air contamination. The building envelope itself may be contributing as well. For this, it is recommended to inspect windows, door seals, closure fixtures, and building weatherization. Older equipment such as washers, dryers, copy machines, and lawn mowers may contribute excessively to air pollution and should be targeted for replacement. Areas suffering from water damage or moisture collection should also be replaced. These include: walls, wallboards, wall coverings, wallpaper, ceiling tiles, and blanket insulations. Establish in-house procedures (including additions to job descriptions) for routinely conducting scheduled inspections. Particular attention should be given to high-risk areas such as open windows directly above air-conditioning exhausts, kitchen vents, and parking garage entranceways. Make certain to address water leaks and moisture problems immediately. Water damaged materials (i.e. paper, linens, carpet, etc.) can develop mold growth within 24 – 48 hours. The Paramount Resort and Conference Center in Gainesville, FL implemented a moisture remediation program, which included sealing the building envelope, sealing the roof by replacing flashing, and installing roof-top air conditioning units that introduce 100% outdoor air that is cooled and dehumidified. End rooms received additional attention, including replacing drywall with materials that resist mold and mildew, sealing interior walls, and installing a moisture barrier (Hinton et al. 2004).

5. **Response/Contingency Plans**. Auxiliary, portable air-cleaners (such as portable filtration or ion units) are commercially available and can be used for rapid response incidents. After each emergency use, remember to check the filters and surfaces and thoroughly clean using the manufacturer's recommendations. Using the data obtained from monitoring indoor air quality (see above), effective action plans can be tailored to respond to specific episodic events. Response may require guest evacuation of certain areas or engaging back-up or stand-by systems.

- **HVAC Preventative Maintenance**. Proper maintenance and monitoring of HVAC operations can greatly improve boiler/cooling tower efficiency and indoor air quality. For instance, every two weeks, a flue gas analysis on the boiler to test fuel-to-air ratio settings should be conducted to adjust fuel-to-air ratio to optimize efficiency and limit the concentration of unburnt hydrocarbons and emissions. Another opportunity is related to reduction of the amount and toxicity of the chemical agents required to treat the water used in these systems.

- **Office Equipment**. Office equipment and supplies emit indoor air pollutants as a result of equipment operation, off-gassing from components (inks, dyes, toner, etc.), or episodic releases related to equipment failure. For equipment that does not use supplies such as a computer monitor, emissions are primarily from off-gassing of residual organics. Fortunately, emissions resulting from off-gassing decrease with time until they reach a point where they are negligible. However, it has been reported that video monitors must be operated for over 300 hours before emissions reach a negligible level (Hetes et al. 1995). Although published data for office product emissions are scarce, a typical photocopier can generate up to 16 – 130 μg O_3 per copy (Hetes et al. 1995), and increased levels of ozone, VOCs, and particulates have been observed in the presence of operating equipment. These contaminants have also been associated with complaints by exposed workers (cited in Hetes et al. 1995).

A variety of simple measures can be employed for the front office, lobby, or back of the house areas to help limit degradation of air quality attributed to office equipment:

1. Copy/print areas can be properly ventilated to the outside.
2. Voltage and temperature settings on printers and copiers can be reduced to limit the generation of ozone.
3. Reformulated toner/ink cartridges with fewer emissions from particulates or solvents can be utilized.

Guest Rooms/Housekeeping

-Energy-

Guest rooms typically account for 40 – 45% of energy consumption in small hotels (16 – 100 kWh/guest night). There are a number of measures that can contribute to energy minimization in the guest rooms. These can be easily implemented into the general practices of the housekeeping department. For example, the following items, many of which have already been discussed earlier, are recommended:

- For unoccupied guest rooms, housekeepers should make certain that all lights are turned off, televisions and radios are unplugged, and the heating/cooling system settings are optimized by resetting the thermostats. This will reduce energy consumption without adversely impacting guest comfort. This can actually be accomplished with building energy management systems that are tied into a central control or by sensor technology. Guest information placards can be added to the arsenal to remind guests about their responsibilities in conserving energy. Finally, hotels can consider sub-metering and charging additional fees for high energy consumption or discounts for meeting energy conservation targets.
- Reduce heat gain in the summer and heat loss in the winter by closing window draperies and shades when exiting guest rooms.
- Use natural lighting when making up and cleaning guest rooms. This will reduce usage of artificial light because housekeeping is typically accomplished during the daylight hours.
- Avoid using hot water for cleaning purposes. This will save electrical costs from water heating and will also reduce water consumption.
- Report and repair leaking water fixtures immediately.
- Maintenance staff can install timers on bathroom heat lamps or even consider connecting bathroom exhaust fans to light switches to reduce excessive operation. The Rosen Plaza and Rosen Centre Hotels in Orlando, FL conducted a brief trial with Energy Star® qualified bathroom fans in 2003. The Energy Star® qualified ventilation fans with lighting used 65% less energy on average than standard models, saving $13 per year in electricity costs. Armed with this data, the Rosen Hotels and Resorts decided to replace the older models in over 2,000 rooms at a potential savings of $26,000 per year.
- Maintenance staff should regularly check and clean HVAC filters as well as the condenser and evaporator coils to keep them running efficiently.

Guest room air conditioning settings should be set down 5 – 8°F when not in use. Inefficient or older HVAC equipment should be upgraded. Replacing a 10-year-old room air conditioner with a new Energy Star® qualified model saves an average of $25 a year on your electric bill. Qualified room air conditioners use at least 10% less energy than conventional models and often include timers for precise temperature control, allowing for better control of the energy required to cool the room. As of March 2007, there are 828 Energy Star® listed models that have exceeded the minimum Federal standard energy efficiency ratio (EER) by 10% to qualify. The Federal standard EER is between 8.5 and 9.8.

When replacing HVAC equipment, it is necessary to ensure that the new unit is sized correctly for the space. If the air conditioner unit is not properly sized (i.e. too large or too small), it will not function at optimal efficiency. An oversized air conditioner is less effective at cooling the room and wastes energy at the same time. Air conditioners remove both heat and humidity from the air. If the unit is too large, it will cool the room quickly, but only remove some of the humidity. This leaves the room with a damp, clammy feeling. A properly sized unit will remove humidity effectively as it cools. An undersized unit will be overworked because it is on all the time and will require more maintenance from accelerated wear-and-tear. The proper sizing is estimated from the square footing of the area to be cooled. Using the square footage and the chart below, determine the correct cooling capacity. Cooling capacity is measured in British thermal units (BTUs) per hour.

Table 6. Proper sizing guidelines for guest room air conditioning units.

Area To Be Cooled (ft^2)	Capacity Needed (BTU/hr)
100 to 150	5,000
150 to 250	6,000
250 to 300	7,000
300 to 350	8,000
350 to 400	9,000
400 to 450	10,000
450 to 550	12,000
550 to 700	14,000
700 to 1,000	18,000
1,000 to 1,200	21,000
1,200 to 1,400	23,000
1,400 to 1,500	24,000
1,500 to 2,000	30,000
2,000 to 2,500	34,000

Adjustments should be made for the following circumstances:

- If the room is heavily shaded, reduce capacity by 10 percent.
- If the room is very sunny or has a south facing window, increase capacity by 10 percent.
- If more than two people regularly occupy the room, add 600 BTUs for each additional person.
- If the unit is used in a kitchen, increase capacity by 4000 BTUs.

Energy Star® qualified central air conditioners have a higher seasonal energy efficiency rating (SEER) than standard models, which makes them about 8% more efficient, on average. Although central systems will likely be more expensive to purchase up front, the cost difference will be paid back over the lifecycle of the unit, through lower electricity bills. The Consortium for Energy Efficiency (CEE) and the Air-Conditioning and Refrigeration Institute (ARI) have developed an online database (www.ceehvacdirectory.org), which can be used to find suitable models that are Energy Star® qualified. When purchasing new equipment, it is important to use an Energy Star® listed contractor to ensure a quality installation. The Air Conditioning Contractors of America (ACCA) Online Contractor Locator (www.acca.org/energystar) includes a special tool to identify contractors who are energy Star® qualified with HVAC equipment. Contractors are not certified, endorsed, or otherwise approved by the U.S. EPA or any other federal agency. A quality installation has the following characteristics:

1. Indoor units and duct system components are installed in conditioned space whenever possible. If they must be located in unconditioned space, they should be well insulated. Outdoor units should be placed away from direct sunlight and kept free of debris. Plenty of room should be allowed for unobstructed airflow on all sides of the equipment. Proper location of the equipment will prevent any unnecessary on/off cycling.
2. Ducts should be sealed and insulated. System efficiency can be increased by as much as 20% by properly sizing, sealing, and insulating ducts. This can also provide more uniform heating and cooling of all of the spaces. The contractor should be able to test the duct system to identify leaks and seal them with mastic, metal-backed tape or aerosol-based sealing.
3. Test and verify airflow. This consists of measuring the airflow at the indoor coil, a component that is installed in the ductwork at or near the furnace or air handler that heats or cools the room air. System testing and any necessary adjustments should be done after duct leakage repairs have been completed. If airflow is too high, duct leakage increases and the temperature at the register is not sufficient for optimal thermal comfort. If airflow is too low, distribution efficiency drops ands accelerates the wear on system components leading to premature replacement.
4. Verify that the cooling system has been properly charged with refrigerant in accordance with the equipment manufacturer's guidelines. Improper refrigerant charge can lower efficiency by 5 – 20% and can ultimately cause premature component failure, resulting in costly repairs that could have been prevented. Since 1992, technicians who handle refrigerants must be certified, so use only certified technicians.

In guest rooms, make sure to place thermostats away from direct sunlight, drafts, doorways, skylights, and windows for optimal performance. Programmable thermostats are preferable to manual thermostats because they automatically adjust the room temperature settings. When used properly (Energy Star® default settings), programmable thermostats are responsible for saving about $150/year in utility costs. The temperature should be set at its energy savings set-points for long periods of time (at least eight hours), for example, during the day, when hotel guests are out sight-seeing, and through the night, when guests are sleeping. Regardless of whether programmable or manual, all thermostats let you temporarily override the setting to make the space warmer or cooler, without erasing the pre-set programming. This override is cancelled automatically at the next program period. Consistently setting the “hold” function or overriding the pre-programmed settings will result in higher energy consumption. Units typically have 2 types of hold features: (a) hold/permanent/vacation; (b) temporary. The hold/permanent/vacation feature to manage day-to-day temperature settings should be avoided. “Hold” or “vacation” features are best when you're planning be away for an extended period. Energy is wasted if the “hold” feature is set at the comfort setting while the room is unoccupied. Guests should be aware that cranking the thermostat up to 90°F or down to 40°F will not heat or cool the space any faster, but it will use more energy. Most thermostats have a programmed time to reach a set-point temperature; however, some units with adaptive learning features will reach desired temperatures by a set time based on historical usage. These functions are not desirable for hotel guest rooms, since the historical usage does not necessarily follow a pattern.

Thermostats should be installed on an interior wall, away from any source of heat or draft such as vents, doorways, windows, skylights, direct sunlight or bright lamps. Some luxury hotels offer suites or apartment/condo style accommodations that utilize multiple heating or cooling zones. For these facilities, one thermostat may not be sufficient. If multiple zones are used, a programmed setback thermostat for each zone should be installed to maximize comfort, convenience, and energy savings. It goes without saying that the thermostat cannot control the thermal comfort and manage the energy expenditures if the batteries need replacing. Some units indicate when batteries must be changed, but not all, so it is good housekeeping policy to check the battery status on thermostats regularly. When selecting an appropriate thermostat, purchase those that do not contain mercury for temperature monitoring.

Water Heating Savings. In the guest rooms, another place to focus energy savings is on hot water. Any measure that will reduce water waste, will reduce the costs of heating that water as well. These include primarily faucets and showers.

- **Faucets**. A leaky faucet that drips one drop of water every second for a year wastes 2,700 gallons of water (Hinton et al. 2004). If hot water is leaking, there are additional hidden energy costs. A visual inspection of all sinks on a monthly basis should be part of the preventative maintenance plan. Replacing a worn washer or gasket ($1/each) can be very effective as well. Federal guidelines mandate that all lavatory and kitchen faucets and replacement aerators manufactured after January 1, 1994 use no more than 2.5 gpm measured at normal water pressures (typically 20-80 psi). Metered valve faucets manufactured after the same date are limited to 0.25 gallons per cycle. Options for water savings in this category include fixture replacement, leak detection, and installation of aerators. Water usage in faucets can also be reduced by using aerator adaptors ($3/each). In the guest bathroom, a 1.5 – 2.0 gpm aerator will provide sufficient water for shaving, hand washing, and personal hygiene purposes. Typical costs for a total faucet fixture retrofit with aerator are $13 – $79 (CH2M Hill 2002).
- **Showerheads**. Showerheads are found in all the residential facilities (guest rooms) of a hotel, although it is not uncommon to find a few shower facilities in the maintenance or administrative areas of the lodging facility. Substantial amounts of water and energy can be wasted through use of inefficient showerhead fixtures. For instance, a brief five-minute shower can consume 15 – 35 gallons of water with a conventional 3-7 gpm showerhead. Showers and baths account for about 30% of the water use in a typical bathroom (Vickers 2001). Replacing showerheads that use 3.0 gpm or more with more modern units that use 2.5 gpm or less can make a significant difference in the amount of water used per room. The payback period can be on the order of 3-4 years depending on the extent of the project (Alexander 2002). Replacing showerheads will not only save water, but also the cost of heating the water. In a recent case study, La Quinta Inn installed low-flow shower heads and aerating faucets in each guestroom, resulting in a savings of $1.50 per room per month in water and energy costs. The typical costs of installing a showerhead replacement are on the order of $34 (CH2M Hill 2002).

Graywater heat-recovery equipment in showers can save 60% of water-heating energy and can double or triple the first-hour capacity of water heaters. Upper floor systems need little or no maintenance; for lower levels, demand-operated pumps are available. Heat recovery systems with heat storage are useful for laundries, where the supply flow is not balanced with drainage; heat storage systems require more space, as well as regular inspection and cleaning. Hotels can obtain “free” hot water from their cooling and refrigeration equipment by using double-bundled heat exchangers in the chillers or a plate heat exchanger in the condenser-cooling loop.

Tankless or on-demand water heating systems either centralized or in individual guest room facilities ca save on water usage but are more energy intensive compared to conventional water heaters. Solar water heating, which can be a viable alternative, is discussed further in the Swimming Pool/Spa section.

-Clean Air-

The indoor air quality of the guest rooms is impacted by a variety of activities in a typical hotel setting. These include: housekeeping/maintenance activities, occupant-related activities (guests), and building-related issues (HVAC), primarily.

- **Housekeeping/Maintenance**. Sierra Environmental Technologies, Inc. suggest that approximately 5 pounds of hazardous chemicals are used in each hotel room per year (2006). The average janitorial worker uses an estimated 28 gallons of chemicals per year, weighing 234 pounds. Hazardous ingredients comprise about 25% of the total, or 58 pounds. The cost for these products is estimated as $250 per worker. Each year 7% of hotel housekeepers report a chemical injury (Barron et al. 1999), and hotel employees are up to 9 times more likely to receive a chemical exposure injury than all other cleaning professionals. In Santa Clara County, 27,000 janitors experienced a total of 1200 injuries each year, and 20% of these injuries were serious burns to the eyes or skin (Barron et al. 1999). Medical treatment and lost job time for these chemical injuries amounted to about $750,000 per year, or about $625 per event. More recent data, has bumped the average cost of each of these chemical related injuries up to over $1500 (Sierra Environmental Technologies, Inc. 2006), which represents an important economic loss to this occupational sector. Extrapolating these estimates to the national level, medical expenses and lost time for chemical injuries to housekeepers throughout the United States may total about $75 - $150 million per year (Barron et al. 1999).

  Switching to environmentally-friendly cleaning agents, avoiding the use of aerosols and air freshening sprays, performing preventative maintenance on HVAC components, and focusing cleaning activities during unoccupied hours will help reduce impacts to the indoor air quality from housekeeping activities. Particular attention should be given to the HVAC and ventilation system. For instance, permanent filters should be cleaned on a weekly basis, disposable filters should be changed out every 1-3 months, and high-efficiency particulate air (HEPA) filters should be used in air handlers. For designated smoking rooms, carbon filters should be used and regularly changed out to control the spread of ETS. More tips were discussed earlier in the Main Lobby/Office section.

- **Limit replaceable items in the guest rooms**. Use refillable dispensers instead of small bottles. Eliminate plastic liners in ice buckets and paper doilies. Eliminate printed information placed in rooms. For example, TV Guide booklets, yellow pages, notepads, and other printed materials may off-gas inks and provide substrate for mold growth if wet.

- **Occupant-related issues**. As stated earlier, some hotels have a stated smoking policy for guestrooms and facilities. Adopting the ETS control strategies identified earlier will help improve indoor air quality related to tobacco products. Limiting cooking activities in the room will also reduce odors and smoke impregnation. Designate outdoor cooking areas that are well-ventilated to keep these activities out of the guestrooms or provide adequate kitchen-style ventilation. Personal care products such as perfumes, hairsprays, deodorants, and cosmetics cannot be controlled by hotel management, but if adequate bathroom ventilation is provided, these emissions can be vented to the outside so that they do not accumulate in the guestrooms. Furnishings and electronic equipment can be carefully chosen to avoid or limit off-gassing of formaldehyde from pressed wood, VOCs from paints, coatings, or carpeting, and ozone from office or entertainment equipment from building up in the guestrooms. Pets are another source of biological contaminants. This issue can be addressed by adopting a no pets allowed policy. Providing guest controls for thermal comfort and exhaust ventilation can help reduce complaints and minimize air quality impacts from episodic events, such as cooking. Providing entry mats can help limit tracked in dirt and pollen. Guests may not always be aware of clean air practices and may even ignore placards and promotional materials designed to educate them on hotel policies on the subject. Therefore, most of the activities targeted to improving indoor air quality must not rely on guest participation. For instance, occupants with communicable diseases may not limit their exposure to other guests or centralized HVAC systems. Thus, it is mainly up to the diligence of housekeeping staff to rigorously clean and disinfect guest quarters and perform routine maintenance and air monitoring to avoid incubating infectious biological contaminants.

Laundry

-Energy-

The laundry facility is comprised of clothes washers and dryers, primarily. One option is to replace obsolete appliances with Energy Star® units, which save water as well as energy. The initial cost is typically higher, but the life cycle costs are substantially lower. For example, full-sized Energy Star® washers use 18-25 gallons of water per load, compared to the 40 gallons used by standard machines. They do this by extracting more water from the load during the spin cycle. This reduces the drying time and saves energy as well as delaying deterioration of linens. Newer top-loading models look like conventional machines from the outside, but use less water and less energy. Many have sensors to monitor incoming water temperature closely. They also rinse clothes with repeated high-pressure spraying instead of soaking them in a full tub of water. Front-loading models are similar to machines used in laundromats. They use a horizontal or tumble-axis basket to lift and drop clothing into the water instead of rubbing clothes around a central agitator. Both top-loading and front-loading Energy Star® qualified washers save water and energy. They also use faster spin speeds to extract more water from clothes, reducing drying time and energy use. Most of the savings comes from using less hot water than conventional models. Therefore, front-loaders will be more energy efficient.

- **Clothes Washers**. Water-saving, horizontal-axis washing machines, also called front-loading washing machines, are documented to save energy, water, and money. Energy efficient guest-operated laundry machines can cost up to $200 – $500 more than conventional systems, but with an estimated annual savings of $250, the payback period is on the order of one year (www.energystar.org). Energy Star® clothes washers which use 50% less energy and 40-50% less water are available for bulk laundry applications as well as guest-operated systems. Compared to models manufactured before 1994, an Energy Star® rated clothes washer can save up to $110 per year in electricity, while using 50% less energy than standard washers. The Modified Energy Factor (MEF) measures the energy used during the washing process, including machine energy, water heating energy, and dryer energy. High MEF values indicate higher efficiency. The MEF is computed as follows (10 CFR Part 430, Volume 62, Number 166, 1997):

$$MEF = \frac{C}{M_E + E_T + D_E}$$

Where C = clothes washer capacity in ft^3 (or liters), M_E = per cycle machine electrical energy consumption in kWh/cycle for the maximum fill, E_T = total weighted per cycle hot water energy consumption in kWh/cycle, and D_E = per cycle energy consumption for removal of the remaining moisture content. To meet the Energy Star® qualifications, the MEF > 1.72.

A value called the Water Factor measures the gallons of water used per cycle per cubic foot (for example, a 2.0 cubic foot washer using 10 gallons per cycle has a water factor of 5.0). The lower the water factor, the less water the machine uses, which means less water that needs to be heated. To meet the Energy Star® qualifications, the maximum Water Factor is 8.0. As of March 2007, there are 225 models that meet the Energy Star® criteria. Energy Star® qualified washers extract more water from clothes during the spin cycle. This reduces the drying time and saves energy and wear-and-tear. Always try to wash full loads. Clothes washers are most efficient when operated with full loads. Another way to save on energy from heating the wash water is to wash clothes in cold water, or at least reduce the temperature setting to 120°F or cooler, if allowed by local codes.

A relatively recent innovation involves the advent of ozone laundering systems, which use cold water, offer savings by using much less water, energy, and detergent. Ozone systems have a 20-year projected life span and can reach payback in 1 to 2 years. In fact, one Maryland hotel installed a $50,000 ozone system that reached payback in just 1 year by cutting laundry hot water consumption in half, reducing wash time from 26 to 15 minutes, and reducing overall sewage costs (E Source 2004).

- **Clothes Dryers**. The ultimate pollution prevention practice for clothes drying would be to air dry clothes whenever possible. However, this may not always be practical. As of 2007, Energy Star® does not label clothes dryers, but to reduce the amount of energy usage from the clothes dryer, implement the following recommendations:

  1. Newer models have moisture sensors that detect when the clothes are dry and automatically shut off the drying cycle, saving an average of 10 – 15% in drying time.
  2. If the clothes washer has spin options, choose a high spin speed or extended spin option to reduce the amount of remaining moisture content (RMC), thus starting the drying process before you put your clothes in the dryer. Less water to heat equates to shorter drying times.
  3. Another energy saving feature to look for is the perma-press cycle, which blows cool air rather than warm air during the drying phase, thus using less energy to heat the air.
  4. Gas dryers use about 12% less energy than electric versions and are 50% less expensive to operate. Consider switching to gas.
  5. Capture and reuse waste heat from laundry operations.

Additional water and energy saving options for laundry facilities include: washing loads at full capacity, adjusting water levels for short loads, reporting leaks and responding promptly, and replacing washers with front loading systems (Defranco and Weatherspoon 1996). For example, washing only full loads provides immediate payback with no upfront costs.

Another pollution prevention technique for reducing energy costs is not to run the laundry systems as often. A linen reuse program that launders bed linens and towels every third day of a guest's stay, unless requested otherwise by the guest, can save lodging facilities up to 30% on water usage and up to $1.00 – $1.50 per night, per occupied room, on laundry expenses (Hinton et al. 2004). Promotional material should be made available in the guestrooms and bathrooms stating the linen reuse policy. However, most guests in hotels that have a linen reuse policy do not request that their sheets be changed more often, so it is usually up to the housekeepers to notice when the sheets actually need changing. In addition to the sheets, towels that are hanging on the racks should not be changed. Only bathroom towels that have been used and are on the floor should be replaced. The American Hotel and Motel Association, which represents over 12,000 lodging facilities in the United States, enacted the "*Good Earthkeeping*" campaign for reusing guest linens and towels, and this program has been enormously successful. Thus an average-sized hotel of 150 rooms can save about $300,000 per year if only 65% of the guests participate in the program (Vickers 2001).

The benefits of linen and towel reuse programs can be quantified by the amount of laundry reduction, amount of labor time on room cleanup reduction, water savings, electricity savings, amount of detergent reduced, and amount of sheet/towel replacement reduced. For example, at 80% occupancy, a Southwest Florida hotel with 100 rooms saved 87,272 gallons of water, 581 gallons of detergent, and $26,718 in energy costs, water bills, detergents, labor, and sheet/towel replacement (White 2004).

A Doubletree Hotel in Portland, OR, installed a $200,000 laundry water recovery system consisting of a pumped closed-loop, three-phase microfiltration and recycling system. The older system heated water to 150°F and then discharged it after one use. The new system recycles the warm water through a screen and a microfiltration unit and returned to the washers for another use. In total, this system saves $40,000 per year in water, sewer, and electric bills, paying back the initial costs in less than 5 years (Vickers 2001).

-Clean Air-

Laundry detergents may contain alkylphenol ethoxylates or non-renewable petroleum-based products. Some detergents still contain phosphates. Other chemicals contain endocrine disruptors and carcinogens (used in fragrance). Synthetic fragrances can cause allergic reactions. Choose dish and laundry detergents and all-purpose cleaners that are botanical-based (i.e. corn, palm kernel, or coconut oil). To remove stains on clothes, try soaking fabrics in water mixed with borax, lemon juice, hydrogen peroxide, or white vinegar. Vinegar and borax are natural fabric softeners. Adding one-half cup of this mixture to the rinse cycle in place of commercial fabric softener will achieve acceptable results.

Avoid antibacterial soaps that promote resistant strains of bacteria. They are not necessary if hand washing is accomplished properly. Bleach and other disinfectants that contain chlorine can generate toxic byproducts such as organochlorines, which are suspected carcinogens as well as reproductive, neurological, and immune-system toxins. Non-chlorine bleach products made from sodium percarbonate or sodium perborate can be just as effective. A solution of 1:1 white vinegar and water can be substituted for almost all disinfection uses. Porcelain and countertops can be cleaned with a paste of baking soda or borax and water or a non-chlorinated scouring powder. Avoid using stain removers with aerosol propellants containing flammable ingredients as well as microscopic particulates that can lodge in your lungs after the water has evaporated. Fragrances can provoke allergic or asthmatic reactions and should also be avoided. If dryer sheets are required, make certain to use the non-scented variety.

Never vent gas clothes dryers or water heaters from commercial clothes washers into the room for heating purposes. This is unsafe. Proper ventilation (as discussed in other sections) will ensure that dryer heat, dust, and lint issues do not become an indoor air quality issue.

Kitchen/Restaurant/Bar

-Energy-

Restaurants and food services are at the top of the list of the most energy intensive commercial activities in Florida, using about 22 times more energy than a family of four, on average. In a survey of restaurants in the Tampa Bay area (cited in Miller 1994), the Florida Energy Extension Service (FEES) found that restaurants annually used 512,000 BTU/ft^2. As expected in Florida, air conditioning is the biggest energy user in the restaurant, responsible for over 40% of the energy consumption. About 38% of the energy used is for food preparation. Refrigeration and sanitation are also important. A decrease in energy use in restaurants by only 5% is estimated to reduce CO_2 emissions by 1.5 billion pounds every year (Miller 1994). Air-conditioning is the biggest energy user in the restaurant, using more than 40% of energy consumed. Food preparation accounts for 38% of energy consumed. Refrigeration and sanitation are the next biggest users.

There are many opportunities to reduce electricity usage in the kitchen and food service areas of a hotel. For instance, in 2000 the Sheraton Seattle Hotel & Towers replaced four kitchen Rotoclone® exhaust fans and conventional kitchen exhausts with variable speed drives. The Rotoclone® fans use water to treat the exhausted air. This change alone saved 43,000 gallons per day with an estimated annual savings of over $80,000 in water and sewer charges (Siegelbaum 2005). However, an exhaust system that automatically varies the fan speed, such as a $15,000 Intelli-Hood system, will eliminate the use of water to treat the exhaust air and reap energy savings on the order of $10,000 in fan power and $10,000 in heating/cooking expenses in the first year (cited in Siegelbaum 2005). Other kitchen fixtures of interest for potential energy conservation in kitchens are dishwashers, garbage disposals, faucets (nozzle-type), and ice machines. The following energy-saving opportunities exist in the kitchen area:

- **Dishwasher options**. Replacing a dishwasher manufactured before 1994 with an Energy Star® qualified dishwasher can save more than $30 a year in utility costs because they are 41% more energy efficient at minimum. There are four main types of dishwashing machines: undercounter, door, conveyor, and flight. All types of dishwashing machines employ wash, rinse, and sanitizing cycles. As of March 2007, there are over 450 models of Energy Star® rated dishwashers available.

  Electricity is required for heating the water for the wash and rinse cycles and providing the steam for the sanitizing and drying cycles. An important step in optimizing the energy requirements is to accurately estimate the appropriate machine size. An oversized system will consume more energy than is actually necessary. Commercial dishwashers use approximately 1.0-1.5 gpm, while conventional rack washers use 9-12 gallons per cycle. Newer units use only 0.75-2.5 gallons per rack (NCDENR 1999). Undercounter washers use the most water and the most energy per cycle, and conveyor types use the least amount of water. Energy efficient, low-flow conveyor washers can reduce water consumption by 43% (NCDENR 1999). An Energy Star® dishwasher saves about $100 over its lifetime, mostly from using less hot water than conventional models. Energy guidelines and water consumption levels for dishwashers are continuing to tighten, and manufacturers are offering more water-saving and energy-saving models. Using an appropriately sized, efficient model will save a significant amount of water and energy. Other important energy saving measures with dishwashers include:

1. **Run dishwashers only when full**. Electric eye sensors can be installed to permit water flow only when dishes are present. In Boston, MA, a dishware-sensing gate saved an estimated 225,000 gallons per year ($2700), and at a cost of only $1200, this measure paid for itself in only 3 months (Vickers 2001). Again, if water-saving practices are implemented, an energy savings will be realized from the reduced energy demand to heat the water.

2. **Recycle final rinse water for washing**. Depending on how often the system is running, the rinse water will be warmer and require less energy to heat up to the desired temperature for washing. This practice will also reduce water consumption.

3. **Minimize hot water losses**. Install door switches for convenient on/off access. Use steam doors to prevent water and heat losses due to evaporation and escape.

4. **Use lower temperatures**. Set operating temperatures to an appropriate level. Systems that are running at higher temperatures will waste more energy to heat the water. Installation of low-temperature machines that rely on chemical sanitizing over high water temperatures will reduce the energy demand for water heating. "Power rinse" cycles should be turning off automatically after a tray has gone through in conveyor systems. Booster heaters should be turned off when not in use. Units should be cleaned regularly.

5. **Use the air-dry option**. Avoid using the heat-dry, rinse-hold, and pre-rinse features, which use additional hot water.

- **Kitchen faucets**. Faucets can waste large amounts of water and hence energy to heat that water, as they are one of the most heavily used items in the kitchen. Pedal-operated faucet controllers will ensure that valves are closed when not in use. Commercial kitchen low-volume, automatic shut-off nozzles typically cost $20-$80. By installing a foot-actuated faucet, one food service facility in North Carolina reduced its monthly water usage by 3,700 gallons; an annual savings of nearly $700 (NCDENR 1999). Brass gasket will not wear out as rapidly as rubber gaskets. Thus, these systems will leak less and consume less energy for heating water. Merely replacing spray nozzles with the newer 1.6 gpm models (versus the older 3-4 gpm nozzles) can save 50,000 gallons of water per year and nearly 2000 kWh of electricity per year (White 2004), while saving $50-$70 per month, on a typical 3 hour/day usage pattern (West 2006).

- **Garbage disposals**. It is recommended that the use of garbage disposal systems be minimized or eliminated from kitchen operations. These devices use 3-8 gpm or more if operating in conjunction with a food scrapping trough. They also consume energy. Many facilities use strainers or traps that employ a mesh screen to collect food waste for proper disposal as solid waste. Another option is to install strainers in sinks, leaving the food matter in the sink for disposal in trash receptacles or composting units. Food debris should be swept into trash cans rather than run through the garbage disposal in the sink. Besides being a large consumer of water waste, this practice leads to grease, food debris, detergents, and other chemicals entering the wastewater collection system. If the debris does not get washed down the drain, it may be swept out onto the asphalt behind the kitchen, where it may ultimately find its way to the storm drain and into our creeks, lakes, and aquifers. Dry cleanup, involving a rubber scraper, squeegee, or absorbent to capture a large portion of the food material or grease to keep it from going down the drain, is recommended as a first pass.

- **Thawing practices**. It takes 30% less energy to cook thawed foods instead of frozen foods (Green 2007). However, running water should not be used to thaw frozen foods or melt ice. Frozen items should be thawed out in the refrigerator overnight, unless the local Department of Health code requires otherwise. If the code requires running water no less than 70°F, then perhaps the flow rate can be reduced or multiple thawing areas can be consolidated into one to use the minimum amount of water and energy necessary.

- **Fats, oils and grease**. Residual fats, oils, and grease (FOG) are by-products from the kitchen. They enter the plumbing system from washing dishes, pots and pans, cleaning the floor, and sanitizing equipment. Sanitary sewer systems are not designed or equipped to handle the grease that accumulates on the interior of the collection system, leading to overflows or sewage backups.

    1. **Operate fryers efficiently.** Blanch or precook foods in a steamer instead of in the fryer. Dry foods before frying to reduce the energy required to heat the moisture content in the food. If the heating elements/coils are partially exposed, 25% of heat energy could be wasted, so fats should be kept away from exposed elements to enable them to operate at minimal heat loss levels. Fat and oils should be melted in a steam-jacketed kettle before frying. The optimal temperature range for frying is 300 – 350°F (Hinton et al. 2004). Purchase Energy Star® qualified commercial fryers with low idle energy rates. Electric units use about 60% less energy than gas fryers based on the 2007 data from Energy Star® qualified commercial fryers.

    2. **Preventative maintenance**. Set up a schedule to periodically service all equipment to eliminate grease blockages. Grease or oil should not be hot-flushed, which leads to liquefied grease entering the main sewer system and escaping the grease traps. Pump out schedules should be established to avoid overflows, downstream blockage, and excessive oil and grease buildup ending up in the drain. Small hoods can be hand-cleaned with spray detergent and wiped down, but professional contractors have specialized equipment that can be more cost effective when dealing with large hood filters.

    3. **Change fryer grease regularly**. Fryer grease should be skimmed and filtered daily; however, the grease should only be changed out when necessary. Build-up of carbon deposits on the bottom of the fryer act as an insulator that forces the fryer to heat longer, which causes the oil to break down sooner. Food grade paper rather than water sprays can be used to soak up oil and grease under fryer baskets.

- **Cooking practices**.

    1. **Do not preheat appliances**. 10 to 15 minutes is adequate to preheat for most applications, if absolutely necessary.

    2. **Schedule food preparation.** Cook some items in off-peak periods. Use more energy efficient methods when possible: ovens, fryers or steamers. Range tops, griddles and broilers are less energy efficient. Stagger times to turn on heavy-duty electrical equipment. Do not turn on all equipment at once. Staggering can lower the

peak demand recorded by utility companies. Also avoid using the range top whenever possible. The range top uses more energy and adds more heat to the kitchen than other equipment. If the range top must be used, be sure to use the appropriately sized pot, keeping them close together to reduce heat losses. Covering pots to reduce heat loss will allow the food to cook faster and allow the cook to turn the heat off early using the residual heat on the burner to finish cooking.

3. **Operate appliances efficiently**. For griddles, preheat for only six minutes, heat only the required portion of the griddle, cluster food close together on the heated portion of the griddle, and cover to reduce cooking times. For ovens, keep doors closed, preheat only when absolutely necessary, do not set the oven temperature higher than necessary, and do not use aluminum foil. Convection ovens are 30% more efficient energy users compared to conventional ovens (Green 2007). Pressure cookers require only 60 watts/hour to bring 1.5 liters of water to a boil. Use lids, which increase cooking energy efficiency by 8-14% (Hinton et al. 2004). Steam cooking is more energy efficient. Therefore, food can be partially cooked in a steamer before being transferred to another method. However, steam tables used for keeping items warm in between serving, waste energy.

- **Exhaust fans and hood systems**. Installing adequate ventilation helps to alleviate many indoor environmental quality issues, primarily by helping to control moisture and removing objectionable odors. Since Energy Star® rated kitchen range hoods, bathroom and utility fans, and inline ventilation fans provide energy savings and are more than 50% quieter than standard models, they are much more likely to be used. Exhaust fans should be used only when necessary and at speeds no higher than necessary. Exhaust fans can waste energy by pulling conditioned air out of the building. Connecting fans to a light switch can control use. As of March 2007, there are 300 energy efficient models that feature high performance motors and improved blade design, which provide reduced energy consumption and longer life. In a hotel setting, bath fans are used more frequently, so the energy savings are potentially even greater. In locations where the fan is run continuously, switching to Energy Star® models can save up to $75 each year.
- **Refrigeration**. As of March 2007, over 1250 models of Energy Star® qualified refrigerators and freezers are available. These units are roughly 45% more efficient than models manufactured ten years ago and use at least 15% less energy than required by current federal standards (National Appliance Energy Conservation Act). Full size freezers (greater than 7.75 ft^3) must be 10% more efficient than the minimum federal criteria, and compact refrigerator/freezers (less than 7.75 ft^3 and less than 36 inches tall) must surpass the 20% threshold. The volumetric capacity is calculated as follows:

  Adjusted Volume (AV) = (Fresh Volume) + 1.63 x (Freezer Volume)

  For freezers, the adjustment factor is 1.73 so the calculation is: AV = 1.73 x Freezer Volume. Fresh Volume is the total volume of the main refrigerator compartment, and Freezer Volume is the total volume of the freezer compartment.

  The energy savings comes from the use of high efficiency compressors, improved insulation, and more precise temperature and defrost control mechanisms to improve energy efficiency. Energy Star® labeled commercial solid door refrigerators and freezers are even more energy efficient because they are designed with components such as ECM (electronically commutate motor) evaporator and condenser fan motors, hot gas anti-sweat heaters, or high-efficiency compressors, which significantly reduce energy consumption and utility bills. Compared to standard models, Energy Star® labeled commercial solid door refrigerators and freezers can lead to energy savings with a 1.3 year payback. The most efficient models consume 0.009 – 0.4 kWh/day per cubic foot capacity, for a reach-in commercial refrigerator and a pass-through commercial freezer, respectively. By buying commercial solid door refrigerators and freezers, purchasers can expect to save $140 annually per refrigerator and $100 per freezer (Westphalen et al. 1996). For large walk-in style refrigeration units, consider installing variable control systems for the evaporator fans, which run continuously while the compressor cycles on and off. Evaporator controls use monitoring devices to determine when the compressor is not running, and then ramp down the voltage to the evaporator fans during the compressor off cycle. Use of these controls can yield energy savings of up to 25%, but not all refrigeration equipment can be adapted in this way, nor are these controls suitable for all restaurant applications (APPA and ASBDC 2003). According to the USEPA and DOE, replacing all existing commercial solid door refrigerators and freezers in the US with Energy Star® labeled models will save $250 million annually, which is equivalent to eliminating the emissions from 475,000 cars (www.energystar.gov). Many Energy Star® rated models include automatic ice-makers or through-the-door ice dispensers, which can also be set to conserve water. Energy Star® qualified freezer models use at least 10% less energy than required by current federal standards. In addition to upgrading the refrigeration unit, energy savings can also be realized by employing the following practices:

1. Position the unit away from any heat source such as ovens, dishwashers, or even direct sunlight. The additional heating load will cause the unit to draw more power to supply the cooling needed for the temperature differential.

2. Allow sufficient air to circulate around the condenser coils by leaving a 1 – 4 inch space between the wall and the unit itself. In addition, if the unit is too full or too empty, it will not operate efficiently. Consider consolidating items and turning off unneeded refrigerators or freezers.

3. Make sure the door seals and gaskets are airtight, and keep the coils clean. Airtight seals will prevent warm moist air from entering the unit and driving the temperature differential in the opposite direction. Also minimizing the amount of time the doors are open will have the same effect. Refrigeration systems can lose 10°F for every second that the door remains open (Green 2007).

4. Maintain the refrigerator at 35 – 38°F and freezers at 0°F. Lower temperature ranges will unnecessarily draw more power.

5. Remember that if you consider upgrading to Energy Star® appliances, recycle older units to minimize waste generation.

- **Icemakers and vending unit**. Energy Star® or VendingMizer® units are available that minimize energy consumption, but the simplest approach is to utilize shading and cover. Locate outdoor icemakers and vending machines under cover and in shaded areas. These machines operate continuously, so by relocating the vending stations to areas under shade, the amount of energy consumed to keep them cool can be reduced by as much as 20% (PA Consulting Group 2001). Direct incident solar radiation is on the order of 1,000 W/m^2 loading to exposed surfaces under peak summer conditions (Parker et al. 1996). From field measurements (Gieger 1957; Abrams 1986; Parker et al. 1996), the difference in localized outside air temperatures from the presence of shade trees or cover can be on the order of 0.6 – 5.0°C (1.0 – 9.0°F), depending on the air movement in the area. This effect can also be significant for air conditioning systems; however, none of the studies previously considered, measured the impact of landscape shading on air temperatures in an air conditioning condenser, which is designed to rapidly process large volumes of air.

Because vending machines operate continuously, energy costs for one refrigerated vending machine can reach $440 per year. Technologies are available that will turn off lighting when no one is near and adjust refrigeration in response to ambient temperatures (E Source 2004). Regularly check and clean condenser coils on icemakers and vending machines. A very thin layer of dust reduces efficiency.

- **Perform regular maintenance**. Periodically check equipment and appliances and replace any inefficient equipment or appliances. Regular maintenance increases efficiency and the life of the equipment. Regularly inspect and clean icemakers and vending machine condenser coils. A very thin layer of dust reduces efficiency. Keep cooking equipment clean. Carbon and grease build-up make cooking equipment use more energy. Operate refrigeration equipment efficiently. Do not set thermostats below necessary temperature, thaw frozen food in refrigerator (it will reduce the load on refrigerator), store food in refrigerators based on frequency of use, do not block circulation within the refrigerator, and locate refrigeration equipment away from heat sources.
- **Install vinyl air curtains or air blowers over the doors**. Vinyl curtains and air blowers reduce the amount of cooled air that escapes and outside air that enters through walk-in doors.
- **Turn off or set back HVAC when the kitchen is closed**. Turning systems off or adjusting the thermostat when restaurants are unoccupied can save a one third or more of total building energy use (Hinton et al. 2004). Be sure to turn off any equipment not in use to reduce the heating load and save on unneeded energy usage.

-Clean Air-

Indoor air pollution hazards may be associated with many types of appliances commonly found in the kitchen. Combustion appliances are those which burn fuels for cooking or heating purposes. Typical fuels are gas (both natural and liquefied petroleum), kerosene, propane, oil, coal, and wood. Examples of these kinds of appliances include ranges, ovens, stoves, furnaces, fireplaces, and space heaters. These appliances are usually safe; however, under certain conditions, products of incomplete combustion can be generated. The types and amounts of these pollutants depend upon the type of appliance, the kind of fuel it uses, how well the unit is installed and maintained, and general ventilation practices during use. Some of the common pollutants include carbon monoxide, nitrogen dioxide, sulfur dioxide, particulates, partially unburned hydrocarbons, and aldehydes. Combustion also always produces water vapor, which is generally not considered a pollutant but in the context of hotel moisture control for mold abatement, can act as one by creating conditions of high relative humidity and wet surfaces.

Vented appliances are designed to be used with a duct, chimney, pipe, or other device that will transport combustion pollutants outside. These appliances can release large amounts of pollutants directly into the kitchen space, if the vent system or exhaust fan is not properly installed, or is blocked or leaking. Unvented appliances release combustion pollutants directly into the kitchen and can be potentially more dangerous to human health. Any appliances that generate carbon monoxide, such as charcoal grills or hibachis should never be used indoors. Carbon monoxide from burning and smoldering charcoal is lethal. There are about 25 deaths each year from the use of charcoal grills and hibachis indoors. Proper selection, installation, inspection, and maintenance of kitchen appliances are extremely important. Appliances should be professionally installed following the most stringent applicable building codes. Improperly installed appliances can release dangerous pollutants in high concentrations and may create a fire hazard. Be sure that during professional installation, backdrafting on all vented appliances is checked.

Providing appropriate ventilation (kitchen hoods and exhaust fans) and correctly locating and using kitchen appliances can also reduce exposures to fats, oils, and grease (FOG) and particulates generated during the food preparation or cooking process. To reduce indoor air pollution, a good supply of fresh outdoor air is required for dilution and also to help carry pollutants up the chimney, stovepipe, or flue to the outside. To improve the efficiency of ventilation in the kitchen, strive to keep doors open to the rest of the kitchen from the room where you are using an unvented or kerosene appliance, and open a window if possible. This allows enough air for proper combustion and reduces the level of pollutants, especially carbon monoxide. If a range is used, consider only operating the unit with a hood fan in place. Make sure that enough outside air is available when using an exhaust fan to pull pollutants outside. If needed, slightly open a door or window, particularly if other appliances are in use. Using a stove hood with a fan vented to the outdoors greatly reduces exposure to pollutants during cooking. For proper operation of most combustion appliances and their venting systems, the air pressure inside the room should be greater than the pressure outside. If not, the vented appliances could release combustion pollutants directly into the room rather than to the outside. Make sure that your vented appliance has the vent connected and that nothing is blocking it. Make sure there are no holes or cracks in the vent. If using a wood stove, open the damper when adding wood to allow more air into the stove. This helps the wood to burn more completely and also prevents pollutants from being drawn back into the kitchen instead of going up the chimney. Visible smoke, or a constant smoky odor inside, when using a wood-burning stove is a telltale sign that the stove is not working properly. Soot on furniture in the rooms where you are using the stove is another indicator. Dishwashing activities may also need to consider separate ventilation, and switching to environmentally-preferable detergents and disinfectants (discussed in the laundry section) is also recommended.

Always use only the correct fuel for the appliance. For example, only water-clear ASTM 1-K kerosene should be used for kerosene heaters. Never use gasoline in a kerosene heater because it can cause a fire or an explosion. Use seasoned hardwoods (elm, maple, oak) that have been aged or cured (dried) instead of softwoods (cedar, fir, pine) in woodburning stoves and fireplaces because the hardwoods burn hotter and more completely. They also form less creosote, which is an oily, black tar that sticks to chimneys and stove pipes. Wet woods form more creosote and smoke. Painted scrap wood or treated wood with preservatives (i.e. CCA) should not be used because they could release highly toxic pollutants, such as lead or arsenic. Plastics, charcoal, colored paper or newsprint, or anything that the stove or fireplace manufacturer does not recommend should be avoided. All kitchen appliances should be used properly. For instance, a range, oven, or dryer should not be used to heat the room. Keep the burners properly adjusted so that the appropriate amount of fuel is consumed. Make certain that doors in older woodstoves are tight-fitting. Old gaskets in woodstove doors may contain asbestos, newer gaskets are manufactured with fiberglass. Always follow the manufacturer's directions for starting, stoking, and putting out fires in woodstoves.

It is recommended that vented appliances be selected whenever possible. Only those that have been tested and certified to meet current safety standards, such as Underwriters Laboratories (UL) and the American Gas Association (AGA) Laboratories, should be considered. Inspect the label to determine if the appliance is safety certified. For example, all currently manufactured vented gas heaters are required to have a safety shut-off device that helps protect workers from carbon monoxide poisoning by shutting off an improperly vented heater. Consider upgrading to newer gas appliances made after 1982 that have a pilot light safety system called an oxygen depletion sensor (ODS). This system shuts off the gas when there is not enough fresh air detected. Older systems will not have this safety feature. Consider purchasing gas appliances that have electronic ignitions rather than pilot lights. Appliances with electronic ignitions eliminate the continuous low-level pollutants generated from pilot lights and are usually more energy efficient as well. Use appliances that are correctly sized. Oversized units will produce more pollutants unnecessarily and are not an efficient use of energy.

There are several commercially available carbon monoxide detectors capable of warning kitchen staff when harmful carbon monoxide levels are reached. Safety devices must never be ignored. When they automatically shut off an appliance, this means that something is wrong. Improper adjustment of gas appliances, indicated by a persistent yellow-tipped flame, can lead to increased pollutant emissions. Request that the gas service provider adjust the burners so that the flame tip is blue. For safety purposes, natural gas, which is odorless, is spiked with small amounts of hydrogen sulfide to impart a rotten egg smell. This is typically done to help alert the user that there is a potentially dangerous leak. Human olfactory senses are capable of detecting minute amounts of hydrogen sulfide; therefore, the smell of fuel should never be ignored. This usually indicates that the appliance is not operating properly or is leaking fuel. If a fuel leak is suspected, shut off the appliance, extinguish any other flames or pilot lights, shut off other nearby appliances, open windows and doors, leave the area, and have it fixed immediately. Have your combustion appliances regularly inspected and maintained to reduce exposure to pollutants. Chimneys and vents should be inspected when installing or changing appliances to determine if modifications are required. For example, if changing from oil to natural gas, the flue gas produced by the gas system could be hot enough to melt accumulated oil combustion debris in the vent. The mobilized debris could block the vent and force pollutants back into the kitchen. Have central air handling systems, including furnaces, flues, and chimneys, inspected annually and properly repair cracks or damaged parts. Blocked, leaking, or damaged chimneys or flues release harmful combustion gases and particles and even fatal concentrations of carbon monoxide. Strictly follow all service and maintenance procedures recommended by the manufacturer, including those that tell you how frequently to change the filter (change filters every 1 – 2 months during periods of use). Proper maintenance is important even for new furnaces because they can also corrode and leak combustion gases, including carbon monoxide. Install and check the operation of smoke alarms and carbon dioxide detectors. Do not forget to check the batteries.

Another aspect is dealing with food waste, which can frequently be a large portion of the waste produced in hotels and lodging facilities (Alexander 2002). At least one hotel waste audit cited in Hinton et al. (2004) showed that the majority of waste in a lodging facility is not produced in the guest rooms, but rather in the food service sector. Over-preparation, table scraps, cooking losses, and packaging failures can lead to accumulation of food waste, release of respirable particles, and accumulation of odors or insects. If preparing foods that have these characteristics it may be necessary to consider providing an area hood to properly ventilate the food preparation areas, just as you would install exhaust fans over gas cooking stoves and ranges. You may want to consider separate functionality or combining ventilation areas depending on the types of appliances, fuels, and usage patterns. Limit kitchen waste by using rubber mats around sinks and dishwashers to reduce glass breakage. Rubber mats will cushion surfaces that tend to cause breakage. Use longer lasting spun glass pads for scrubbing pots and pans instead of steel wool. The iron metal fibers from steel wool pad can become airborne when dried and inhaled by kitchen workers or land on prepared food and ingested by restaurant patrons.

For hotels with bars or night clubs on the property, ETS control is also an issue.

Conference Areas/Meeting Rooms

-Energy-

Opportunities for reductions in water use for the conference areas and meeting rooms are similar to the main lobby/office section (i.e. lighting, motion sensors, programmable thermostats, etc.). In addition, to reduce energy waste in convention areas is to avoid serving food and beverages that require heating or chilling to well beyond room temperatures (Convention Industry Council 2004). Thus steam tables and ice buckets will not have to be employed unless absolutely necessary. Ice water should only be provided to guests when requested, and water glasses should not be filled until close to the end of the session or meal to save on the energy to make ice.

-Clean Air-

Depending on the size of meeting rooms, this is one area that could provide a highly visible way for hotels to focus on indoor air quality. Many of the applicable practices for improving indoor air quality in the meeting rooms and convention halls have already been discussed in the Main Lobby/Office sections.

Grounds

-Energy-

One of the best ways to save energy on the grounds is to install solar accent lighting. Outdoor lighting was discussed previously. Another target for potential savings is the pumping of water for irrigation purposes. The volume of water used for lawn and landscape irrigation in hotels is not well documented. Residential outdoor water use in South Florida can be on the order of 30-50% of the total demand. Extrapolating these typical irrigation demands to hotels would likely lead to gross exaggeration. However, estimates from studies in Tampa and Pinellas County, show that on a per capita (guest) basis, the percentage is extremely low, on the order of 2-7% (West 2006). Landscaping use is likely to be variable, depending highly on the area, plant types, climate, rainfall, water costs, maintenance practices (i.e. frequency of sidewalk cleaning), and the number of golf courses and outdoor amenities. There are many available water-saving landscape options designed to promote water conservation that will also reduce pumping costs:

- **Xeriscaping.** This term, coined by the Denver Water Company to promote water conservation, refers to the art of minimizing water usage for irrigation by proper planning and design, soil analysis, selecting appropriate plants (drought-tolerant or native species), selecting practical turf areas, operating efficient irrigation schedules and systems, use of moisture-retaining mulches, and appropriate maintenance programs. Water-Wise is a water use efficiency program developed by the USEPA to promote conservation efforts like xeriscaping. More information on this program can be obtained by visiting www.epa.gov.
- **Florida Yards and Neighborhoods Program**. This program was developed by the University of Florida Institute of Food and Agricultural Sciences Extension (IFAS Extension) to promote conservation of water, reduce storm water runoff, decrease non-point source pollution, enhance wildlife habitat, and create beautiful landscapes (http://hort.ufl.edu/fyn/object.htm). In order to promote Florida-Friendly Landscaping, several measures are recommended:

1. **Efficient watering**. The most straightforward method of minimizing water consumption is to carefully design a landscape that receives sufficient amounts rainfall to thrive, while requiring minimal amounts of supplemental irrigation water. For instance, a lawn in full sun will require more frequent irrigation than a plant bed of drought-tolerant shrubs and groundcovers under a canopy of shade. However, even an ideal landscape can be over-irrigated. Therefore, care must be exercised in irrigation scheduling. If watering is necessary, grounds should not be watered during the daylight hours to reduce evaporative losses; soaker hoses should be used in place of sprinklers; hose connections should be checked for leaks; trees and flower beds should be mulched; and sidewalks, driveways, and parking lots should be swept instead of hosed down (Defranco and Weatherspoon 1996).

2. **Plant selection**. Careful planning and site evaluation are necessary because Florida is a diverse state with multiple climatic zones, soil types, temperature ranges, and precipitation patterns. It is not uncommon for widely different conditions to exist within the same property. Local codes often dictate which species may be planted in certain municipalities. Therefore, the appropriate agencies should be consulted when developing a landscaping plan. Whenever possible, it is recommended to select drought resistant plants that require less water. Many of these will likely be native plants, which tend to thrive only on rainfall. Remove invasive exotic plants and replace with appropriate natives or other non-invasive exotics. Native and other "climate appropriate" landscape materials can reduce irrigation water use by more than 50%. An additional benefit to using native plants is that they tend to attract wildlife.

3. **Fertilize appropriately**. Fertilize in moderation and only during the growing season. Use fertilizers that contain slow-release, water insoluble forms of nitrogen, or use organic compost (possibly from in-house food waste recycling). Many trees and landscape plants demand little or no fertilizer once they are established. When over-applied, fertilizers aggravate insect and disease problems and create excessive growth issues, increasing the frequency of mowing or pruning. Excess fertilizers can run off into waterways or leach into the aquifer, polluting the source of drinking water.

4. **Mulching**. Mulching flower beds, shrub beds and trees can have several benefits. It helps the soil absorb water, allows water to better penetrate plants root systems, reduces soil erosion and unwanted weed growth, and moderates large changes in temperature. As the mulch decomposes, the organic content of the soil is increased. Mulch also increases the attractiveness of areas. A 2-to-3-inch layer of organic mulch over the roots of trees and shrubs and in plant beds is sufficient (Hinton et al. 2004). Self-mulching areas can be created under trees, so that leaves can stay where they fall. In a Florida Yard, grass clippings, leaves, and yard trimmings are turned into mulch to return valuable nutrients to the soil. By-products or alternative mulches such as pine bark, eucalyptus and melaleuca, or recycled mulches may be available from your community, after a hurricane cleanup for example. This opportunity should be taken advantage of by consulting the local solid waste management authorities. Often mulch can be made available free of charge.

5. **Replace mowed landscaping with ground cover**. Plan the landscape with minimal use of turf grass. Only plant grass that requires watering and mowing where it is necessary for guest satisfaction. Replace grass with ground cover that requires less maintenance and less water. Try to eliminate small areas of grass, such as parking islands and areas between sidewalks and roadways. These are hard to maintain,

require a lot of watering and may be replaced with mulch without losing any of the decorative appeal.

- **Employ the most efficient irrigation methods**. Sprinklers should be used for lawns, bubblers for trees, drip irrigation for gardens and shrubs, and soaker hoses for flower beds and ground covers. Wherever possible, trickle, drip, or soaker hose irrigation systems should be used because they consume less water than sprinklers. If sprinklers are used, select slow releasing heads, close to the ground, in contrast to those that release a mist, which tends to evaporate more easily. Place sprinklers at the top of sloped areas so that the water that runs off ends up irrigating the entire slope. Heads should be aligned with the areas that they are intended to water. Always check when irrigation systems are operating to insure they are not watering sidewalks and driveways.

    1. **Leaks**. If water drips or leaks from sprinklers after being turned off, the sprinkler should be replaced or repaired. Hoses and lines should be routinely checked for punctures and repaired or spliced. When using a hand hose to water new plantings, a nozzle to control the amount of water consumed is recommended. Just as with indoor leaks, outside leaks can increase the water bill substantially. A leaky faucet that drips one drop of water every second for a year wastes 2,700 gallons of water (Hinton et al. 2004). A visual inspection of all hoses, faucets and sprinklers should be done on a monthly basis.

    2. **Irrigation times**. The best time to irrigate is during the early morning or early evening hours when temperatures and wind velocities are at their lowest. Water evaporates quickly during the daylight hours, and during windy conditions, water may not reach targeted areas or may fall onto paved areas. Often, municipalities or water management districts have specified local regulations for watering times. Standard restrictions include no irrigation between the hours of 10 a.m. to 4 p.m. There may be additional restrictions, particularly during drought conditions. Irrigation is not necessary during a rainfall event; therefore, any new irrigation system is required by law (Chapter 373.62, Florida Statutes) to have a rain shut-off device or sensor that will override the system.

    3. **Metering**. Irrigation systems also can be metered and set to deliver a specified amount of water.

    4. **Avoid ponding**. Irrigate thoroughly, slowly, and less often. Reduction of irrigation time and application of other appropriate measures can equal a potential savings of 4.5 million gallons of water and $8,833 each year (White 2004). Lawns should be watered so that the soil is moist to a depth of 4-6 inches (Hinton et al. 2004). It is preferable to irrigate thoroughly (so water reaches the root systems) once each week than to water lightly each day. Watering lightly can damage the lawn because only the surface, rather than the roots, may be reached. Watering should be done slowly to avoid runoff. Sandy soil absorbs water quickly but does not retain moisture. Adding mulch will help correct these problems. On the other hand, over-irrigation can also result in problems such as excess water runoff carrying fertilizers and pollutants into our waterways. It can also result in diseases, such as fungus, and in the excessive growth of weeds and pests. Too much water promotes weak growth, which increases the frequency of pruning and mowing as well as likelihood of damage resulting from storms. Less frequent watering encourages deeper root development and healthier turf. Using chemicals to compensate for the results of over-irrigation exacerbates the problem by increasing stormwater runoff pollution.

-Clean Air-

For the grounds, lodging facilities should minimize or eliminate the use of toxic herbicides, fungicides, and biocides, fertilizers, and CCA-treated wood that contains copper, chromium, and arsenic. These items will find their way into the HVAC system through the outside air intakes or be tracked into the building through any of the entry points. If termites are a concern, consider replacing pesticide application practices with non-toxic products like Termimesh® systems, which employ a physical barrier approach rather than a chemical inactivation (Upton 2007). If xeriscaping or native plants are used for ground cover, make certain that plants with little or no pollen are selected near building entryways. In addition, plants should be selected that require little or no pesticide or fertilizer application and minimal watering. This will have the effect of minimizing chemical usage and also minimizing the potential for ponded water as a breeding ground for biological contaminants or moisture entering the building. Pallets used to bring in supplies may be built using CCA-treated wood. Specify to your supplier that pallets must not contain CCA.

Another area to pay particular attention to would be the chemical storage facilities. Regular inspections should be conducted to check that cleaning solvents, paints (containing Pb or VOCs), fuels, and other chemicals are properly stored, containers are closed tightly and not leaking or spilling into entryways or running off into storm sewers. It is recommended that work areas be vented independently.

Another opportunity is to explore alternatives to gasoline-powered vehicles and non-road engines. Alternative Fueled Vehicles (AFVs) operate without gasoline and instead run on methanol, ethanol, compressed natural gas, liquefied petroleum gas, bio-diesel, electricity, and others. Some AFVs can run on a mixture of conventional and alternative fuels. These hybrid vehicles are more practical unless you have easy access to an alternate fuel supply. If alternatives to conventional fossil fuels are not feasible, then anti-idling campaigns should be focused on these areas as well.

Loading docks, shop activities, odors from dumpsters, and building exhaust systems located near outdoor air intakes are all potential sources of outdoor pollutants that can potentially degrade indoor air quality. These activities should be carefully planned to minimize the impact to outdoor air intakes and should be properly ventilated even if conducted outdoors. Any activity that produces particles and dust, like trimming landscaping, painting, or wood shop repairs, should be limited or conducted in isolated areas, offsite preferably.

For outdoor cooking areas, special precautions should be in place when operating fuel-burning or unvented combustion sources near entryways or areas that are not well-ventilated. Generators for backup power should also be installed and located properly, periodically checked for leaking fuel and proper operation, and during use, carbon monoxide should be monitored.

Swimming Pool/Spa

-Energy-

Energy use in swimming pools and spa facilities varies depending on size, design, climate, and water quality and treatment requirements. Heating pools and spas is a major energy drain and increases the water demand due to enhanced evaporation from higher temperatures. As stated in earlier sections, any practice that reduces water loss will reduce the heating requirements of replacement (make-up) water. For instance, pools are often drained and refilled more often than truly necessary. This frequency should be limited to only when absolutely essential. However, water must be added routinely to replenish losses due to evaporation, splashing, leaks, and filter backwashing. One way to reduce such losses is to invest in an insulated pool cover, particularly for spa facilities, which operate at higher temperatures. About 95% of pool water lost to evaporation can be saved by using a pool cover (CDWR 1998). An average uncovered outdoor pool loses up to 1 inch of water per week during the summer months due to evaporation (Vickers 2001). To reduce evaporation and retain heat in pools, humidity should be maintained at 50 – 60% with temperatures at 2 – 4°F above the water temperature (80 – 85°F for swimming and 97 – 102°F for whirlpool/spa). In addition, lowering the pool water level will help to reduce the amount of water lost to splashing. If fountains, waterfalls, slides, sprayers, or other features are used, replace them with water features that use recycled water if the water is heated, or simply turn them off so that they operate only when truly necessary. This will reduce evaporation as well as energy consumption due to pumping costs.

Additional energy savings can be obtained through the following practices:

- **Optimize energy settings**. Consider lowering the operating temperature setting. Each degree Fahrenheit can cut energy consumption by 5 – 10% (Ohlsen 2007). Also by installing a high-efficiency pool pump that is not oversized for its needs, the pump will consume the minimum amount of energy to operate. If a pump runs for three hours instead of eight hours, energy consumption can be cut by up to 60% without noticeable degradation in water quality.
- **Use timers on pool and spa heaters so that they turn off after hours**. Turning heaters off after hours will reduce energy consumption and wear and tear on the equipment, which will help them run more efficiently.
- **Close outdoor pools and spas in the off-season**. If temperatures drop low enough, guests will tend to avoid swimming in outdoor pools and spas. During these periods, it is recommended to consider closing these facilities to avoid wasting energy. Savings will be realized in terms of the costs to operate pumps, filters, water heaters, and other energy consuming equipment every month that these facilities remain closed. When not in operation, consider draining or covering the pool or spa, so that the filter units and pump systems can be taken off-line. For instance, a 10-hp pump motor consumes up to $2000 in electrical costs when running continuously for 6 – 8 months (Hinton et al. 2004).
- **Consider a solar heated pool**. Solar heating swimming pool systems are one of the most economical forms of solar energy available today. The systems can be easily added to new and old swimming pools, often using an existing filter pump system. Solar water heating systems for preheating swimming pools and spas. Consider a solar water heating system. Solar water heating systems can dramatically reduce energy and maintenance cost at hotels, which use large amounts of hot water.
- **Perform preventive maintenance**. Regularly scheduled preventive maintenance will help equipment run more efficiently and, therefore, reduce energy consumption. The skimmer and pump strainers should be cleaned frequently to help reduce strain on the filter mechanism that will lead to loss in motor efficiency. By trimming foliage around the pool and spa, the need for filtering will be reduced.

Indoor swimming pools require simultaneous heating and dehumidification. Heat-pump water heaters are an ideal solution to efficiently serve both of these needs: They heat water and also produce cool air, which can lower the pool room temperature and humidity. If traditional equipment is a must, look for a highly efficient condensing boiler and use variable-speed drives on pump motors, which can reduce pump costs by more than 50 percent. Low-temperature unglazed solar water heaters are an inexpensive approach well suited for swimming pools and spas in some climates. Glazed flat-plate collectors can provide higher-temperature water (E Source 2004).

-Clean Air-

These areas provide additional opportunities for clean air practices for pools and spas.

- **Repair or replace pool furniture.** Make certain that outdoor furniture does not contain materials that are off-gassing or are likely to foster mold/mildew by trapping moisture.
- **Control chemical use.** Cleaning chemicals should be biodegradable and as least toxic as possible to get the job done. Choose pump sprays instead of aerosols. Use products in correct concentration and as recommended by the manufacturer. This saves the amount of product needed. The supplier may be able to provide the strength necessary for cleaning. Over-chlorination is not necessary, and there are non-chlorine based sanitizing agents available now. Check into alternatives for chlorine to minimize the use of a hazardous substance. Both copper/silver ionization and ozone disinfection are proven technologies used to sanitize water for several different applications without chlorine. Any way to reduce odors from disinfection or chemical stabilization will improve air quality.
- **Minimize hazardous waste by inventory.** Know what you have in inventory and what you need to get the job done. Just-in-time inventory methods can reduce the need to store chemicals and other products, and thereby limit off-gassing and odors.
- **Use pollution prevention strategies for the spa.** In the shower areas, use leftover amenity soaps and shampoos from the guest rooms, if the seal has not been broken. Or, use bulk soap and shampoo dispensers. Air-conditioning with dehumidification should be used year round to control humidity in these areas.

Barriers

Legal, policy and social barriers to implementation of conservation measures

Some green lodging practices simply cannot be implemented due to local health codes and legal restrictions. For other measures, we may be forced to look at a tradeoff between energy conservation and indoor air quality for example. Beyond these limitations, there are three major obstacles that typically frustrate lodging managers from communicating their preference for environmentally responsible hotel services:

1. A perceived lack of information and resources about environmental options.
2. A lack of ability to research the environmental performance of hotels.
3. A perceived prohibitive cost issue.

Let us tackle each of these barriers one by one. With regards to the lack of information issue, sadly there is some truth to this perception. While institutional purchasers are inclined to favor green hotel services, they need improved access to environmental information in order to include such considerations in their purchasing decisions. The available information must be put in a form that can be easily implemented by an average hotel manager. Fortunately great strides have been made in this area. For instance, the USEPA has a pair of comprehensive websites with excellent information regarding environmental standards related to purchasing and procurement.

1. EPA Procurement: http://www.epa.gov/epaoswer/non-hw/procure/index.htm
2. EPA Buy Recycled http://www.epa.gov/epaoswer/non-hw/muncpl/buyrec.htm

However, during the course of the literature review found herein, it can be seen that many of the green practices outlined in this report were proposed 10-20 years ago. Many of those recommendations have payback periods on the order of months or even generate income on the order of tens of thousands of dollars per year, and yet so many have not been put into practice.

The second perception refers to a lack of performance measures. Again, during the course of the literature review for this document, the authors have come across literally hundreds of success stories and case studies detailing the environmental performance and economic benefits of green lodging practices. What is missing is to put these success stories in the context of non-participating hotels is to express the results into the language or business jargon of the decision-makers. This concept must be explored further using interdisciplinary means. At first glance, it may involve computing a rate of return on investment, a cash-flow diagram, or some other method.

The third perception is the prohibitive cost issue. Although a number of incentives are in place such as environmental product labeling and green hotel certification, the vast majority of hotel operations have not embraced the green lodging movement. At the corporate scale, the industry lacks a clearly articulated motivator to make significant changes. This is complicated by the fact that most brand name hotels have a complex management scheme involving the property ownership group, the operations management company, and the corporate flag. Since decisions are not made at the local level and require months of study for standardization and training and communication prior to adoption, implementation of green principles is a slow moving process. Certainly, the current environmental guidelines available to the industry do not provide sufficient information or are themselves too complex and not practical enough for the average hotel manager to implement. However, the cost issue, which has been shown to rarely be a driving force acting against implementation, can be a real problem because the management group annual budget may require ratification from the ownership group and the flag. Thus capital expenditures required to establish some green lodging practices may be difficult to secure for larger corporate hotels. Because it “takes money, to make money,” the prohibitive cost issue is often used as an excuse. At the smaller level, those hotels that are owned and operated by the same group or person tend to follow the leader of the larger hotels to attract a more diverse customer base, which is accustomed to policies and operations of big chain hotels, and to stay competitive in the market.

The perceived cost issue leads us to the “bang for the buck” issue. The question of which improvement should the hotel implement with limited resources is easily answered by which measure saves the most money, right? Well the answer is often not so straightforward. Take the following statement for example: the Hyatt Regency Coconut Point Resort and Spa reduced its water consumption by 28% and reduced its waste by 2.8%. This makes it appear that the water conservation efforts saved 10 times more, but after closer inspection, we can determine that the solid waste disposal costs were 20 times more on an annual basis, so we can conclude that the waste reduction efforts saved the most money. This example illustrates the communication issue that well-intentioned green lodging proponents have, and highlights the divide between the wealth of data in support of green measures and the conflicting message to decision-makers.

With respect to solid waste management issues, the recent trends of recycling programs provide an important lesson. According to the American Hotel and Motel Association (AHMA), between 1996 and 1998 the percentage of AHMA members offering recycling services dropped from 59% to only 46%. Larger, luxury hotels continue to offer recycling services, while economy lodging properties are less and less likely to offer such a service. However, waste prevention measures such as towel/linens programs, soap dispensers, and hand dryers are being used more now than in the past. Reasons may include poor pricing for recycled materials, labor shortages, or lack of competitive recycling services (NHDES 2001).

Educating guests about recycling through guest cards, media boards, and in-house television is a great public relations tool that is received favorably by guests. Many guests are familiar with recycling from home or work and are glad to continue the process when in a hotel. However, hotels often hesitate to establish programs in solid waste management because of the coordination and cooperation needed among management, employees, and guests. Nevertheless, the very real cost benefit remains an incentive. (Alexander 2002)

Typical fallacies about recycling can be seen in the lodging industry literature. For example, “Recycling programs can often save money, but if the time required to separate the waste is too great, or the procedure too impractical, frustrations and increased time-pressure on employees could negate any dollar savings” (Florida Hotel & Motel Journal, June 1999). Here is another quote from the same journal: “Waste representatives often fail to encourage their clients to recycle because recycling waste is less expensive to dispose of than commingled solid waste (regular garbage)” (Florida Hotel & Motel Journal, June 1999). This is the difficult environment in which the green lodging movement must overcome.

With regards to water conservation, we will focus on equipment versus behavioral measures. In Seattle, WA, a pilot program investigated water conservation opportunities related both to replacement or significant upgrades to existing equipment, and “behavioral measures” related to equipment maintenance and to employee/guest education. Many commercial water conservation studies have focused exclusively on equipment measures. However, without adequate employee education and establishment of regular maintenance schedules, water savings projected for equipment replacements may not be achieved, leading to distrust in other projected green lodging savings estimates (O’Neill & Siegelbaum and The RICE Group 2002). It is far more likely that a one-time event like replacing all showerheads with low-flow fixtures for example will be undertaken, rather than routine leak monitoring, which is a long-term maintenance issue. A likely reason for this is that the purchase and installation can be done at the management level and contractor level, respectively, but the routine monitoring is typically accomplished by the housekeeping or maintenance staff, which has little incentive. In addition, new shiny faucets, drench-style showerheads, and fancy toilets give the perception of luxury, but luxury is not always compatible with water conservation.

Many water conservation opportunities provide opportunities for energy savings at the same time. For example, two hotels in the west coast of Florida were audited, and the potential water savings equaled approximately one-third of the current water consumption. For the older Westin Hotel, close to 90% of the projected savings were from “equipment measures” primarily related to upgrades in restrooms, ice machines and laundry equipment. For the West Coast Grand Hotel, a converted office building, close to 90% were for “behavioral” measures, primarily related to maintenance and operation of heating and cooling equipment. What is needed is a commitment to do both in order to achieve the most savings success.

However, determining success is based on more than the water saved in any given year. Rather, success might be measured by whether those changes are part of a long-term strategy that is integral to the hotel’s philosophy and practice, versus the “flash in the pan” result of an environmental champion whose departure will impair long-term environmental improvement. (O’Neill & Siegelbaum and The RICE Group 2002).

Finally some hotels are reluctant to pursue environmental projects because they are concerned about how the projects will be accepted by their guests. For the most part, surveys have typically shown that hotel guests are concerned about indoor air quality and the environment, and they are even willing to pay a premium to demonstrate that commitment. In fact, many hotel guests are specifically looking for environmentally friendly hotels or motels. The American Hotel and Motel Association Hotels conducted an informal survey of the Dadeland Marriot Hotel guests who stayed in one of the 38 guest rooms outfitted with futuristic technologies for water conservation, indoor air quality, and energy minimization. Even thought the rooms cost over $10 per night more than the regular rooms, guests specifically requested them when making reservations on following visits (Riggle 1992). Thus, the “green room” concept can enhance the image of their property by showing visible signs of environmental management such as recycling bins or compact fluorescent lights. Hotels that practice energy efficiency, water conservation, and recycling; save dollars and encourage environmentally sensitive guests to choose their hotel over the competition.

Partners

- Antrac Technologies, Inc.
- BTEX Engineering Inc.
- Dade Paper
- EcoSMART Technologies, Inc.
- Ecotech Water LLC
- Greening the Cleaning
- ICI Paints
- Niagara Conservation Corporation
- Oxygenics
- Ozone Solutions
- Pineapple Hospitality Inc.
- Premium Services Refrigeration Company
- ProTeam Inc.
- Rejuvinair Inc.
- SOMS Indoor Air Quality, LLC
- SP Recycling Corporation
- Zinsser Company Inc.

Candidate Hotels

According to scope of work, quantifiable improvement will be related to the number of guest rooms occupied within the lodging property. For purposes of comparison, candidate hotels will be sub-divided into four classes of establishments:

1. Hotel and convention center multipurpose facility (800 + rooms)
2. Large chain hotel (300 – 500 rooms)
3. Motel (< 100 rooms)
4. Bed and Breakfast

In addition, the occupancy rate of a hotel varies as a function of seasonal and economic factors. To facilitate comparisons, control hotels will be used with similar occupancy rates and will be monitored over the same study period. For example, with a national chain hotel, a candidate hotel will be selected for project implementation and a similar sized hotel from the same chain, if possible, in a nearby location will be selected as the control. Monitoring will also focus on the 12-month period prior to implementing any changes as well as the immediate 6 month – 2 year period following implementation.

In Phase 1, a pair of candidate hotels have been preliminarily identified and are described below.

- The Four Seasons (Miami, FL) is located at 1435 Brickell Avenue, Miami, Florida 33131, just one block from Biscayne Bay, in the business district of downtown Miami. The facility is a 70-story tower of luxurious guest rooms and suites with views of the city and bay. The hotel has 221 spacious guest rooms including 182 standard sized rooms of 500 ft^2, 15 executive suites (750 ft^2), and 24 luxury suites (>1000 ft^2). Amenities include: fitness facilities, pools, spa, business services, high-speed wireless internet, one restaurant and two lounges, as well as a variety of other high-end services for guests. The hotel also has over 20,000 ft^2 of conference, boardroom, classroom, and banquet hall space.

- The Four Seasons Resort Palm Beach (West Palm Beach) is located 2800 South Ocean Boulevard, Palm Beach, Florida, 33480. The facility offers 210 guest rooms, including 13 suites, featuring private, furnished balconies with views of the ocean or the Resort's landscaped gardens and pool area. The standard guest rooms (196) are of varying sizes (546, 439, 393 ft^2) and the suites vary from 685 to 1370 ft^2. Amenities include: fitness facilities, pools, spa, business services, high-speed wireless internet, two restaurants and one lounge, as well as a variety of other high-end services for guests. The hotel also has over 34,000 ft^2 of conference, boardroom, classroom, and banquet hall space.

As part of Phase II, several other hotels have pledged to participate in the implementation testing program.

THE SHORE CLUB

Date

Daniel E. Meeroff, Ph.D.
Department of Civil Engineering
Florida Atlantic University
777 Glades Road, Building 36, Room 222
Boca Raton, FL 33431-0991

Dear Dr. Meeroff:

First, let me thank you for inviting our property, Shore Club Hotel, to participate in the State of Florida's *Green Lodging* Certification Program and also in the current research initiative that Florida Atlantic University (FAU) is conducting in partnership with the Florida Department of Environmental Protection (FDEP). By this letter, we are committing our support of the program and agree to be a participant in the FAU research study. As an organization, we have received the appropriate level of commitment from the hotel's management to enter into this agreement and ensure its implementation.

Over the course of the study, we understand that we will likely be asked to attend a small number of onsite meetings, allow designated FAU students to conduct an onsite assessment, and provide specific data on the following topics: waste generation volumes and costs; purchasing records for supplies and some services; energy consumption and costs; water consumption and costs; and seasonal occupancy rates. We further understand that all of the aforementioned data will be kept confidential and used for the sole purpose of examining the quantitative aspects of our current environmental programs and their future enhancements.

We look forward to working with FAU and FDEP on this exciting project and are anxious to take the next steps in forwarding the program.

Yours truly,

[signature] 9/7/06
General Manager

Interested in the analysis to be completed to understand the benefit of such program. before going forward.

1901 COLLINS AVENUE MIAMI BEACH FLORIDA 33139
PHONE 305 695 3100 FAX 305 695 3299 RESERVATIONS 305 695 3222 SHORECLUB.COM

April 17, 2007

Daniel E. Meeroff, Ph.D.
Department of Civil Engineering
Florida Atlantic University
777 Glades Road, Building 36, Room 222
Boca Raton, FL 33431-0991

Dear Dr. Meeroff:

First, let me thank you for inviting our property, PGA National Resort & Spa, to participate in the State of Florida's *Green Lodging* Certification Program and also in the current research initiative that Florida Atlantic University (FAU) is conducting in partnership with the Florida Department of Environmental Protection (FDEP). By this letter, we are committing our support of the program and agree to be a participant in the FAU research study. As an organization, we have received the appropriate level of commitment from the hotel's management to enter into this agreement and ensure its implementation.

Over the course of the study, we understand that we will likely be asked to attend a small number of onsite meetings, allow designated FAU students to conduct an onsite assessment, and provide specific data on the following topics: waste generation volumes and costs; purchasing records for supplies and some services; energy consumption and costs; water consumption and costs; and seasonal occupancy rates. We further understand that all of the aforementioned data will be kept confidential and used for the sole purpose of examining the quantitative aspects of our current environmental programs and their future enhancements.

We look forward to working with FAU and FDEP on this exciting project and are anxious to take the next steps in forwarding the program.

Yours truly,

Joel Paige
Managing Director

PGA NATIONAL RESORT & SPA ®
400 AVENUE OF THE CHAMPIONS • PALM BEACH GARDENS, FL 33418-3698
phone 561-627-2000 *fax* 561-227-2595 www.pgaresort.com

CARLTON HOTEL
SOUTH BEACH

April 30, 2007

Daniel E. Meeroff, Ph.D.
Department of Civil Engineering
Florida Atlantic University
777 Glades Road, Building 36, Room 222
Boca Raton, FL 33431-0991

Dear Dr. Meeroff:

First, let me thank you for inviting our property, The Carlton Hotel South Beach, to participate in the State of Florida's *Green Lodging* Certification Program and also in the current research initiative that Florida Atlantic University (FAU) is conducting in partnership with the Florida Department of Environmental Protection (FDEP). By this letter, we are committing our support of the program and agree to be a participant in the FAU research study. As an organization, we have received the appropriate level of commitment from the hotel's management to enter into this agreement and ensure its implementation.

Over the course of the study, we understand that we will likely be asked to attend a small number of onsite meetings, allow designated FAU students to conduct an onsite assessment, and provide specific data on the following topics: waste generation volumes and costs; purchasing records for supplies and some services; energy consumption and costs; water consumption and costs; and seasonal occupancy rates. We further understand that all of the aforementioned data will be kept confidential and used for the sole purpose of examining the quantitative aspects of our current environmental programs and their future enhancements.

We look forward to working with FAU and FDEP on this exciting project and are anxious to take the next steps in forwarding the program.

Yours truly,

Jason Winberg
General Manager

RIVERSIDE
HOTEL
EST. 1936

August 23, 2006

Dear Dr. Meeroff:

First, let me thank you for inviting our property, the Riverside Hotel, to participate in the State of Florida's *Green Lodging Certification Program* and also in the current research initiative that Florida Atlantic University (FAU) is conducting in partnership with the Florida Department of Environmental Protection (FDEP). By this letter, we are committing our support of the program and agree to be a participant in the FAU research study. As an organization, we have received the appropriate level of commitment from the hotel's management to make this commitment and ensure its completion.

Over the course of the study, we understand that we will likely be asked to attend a small number of onsite meetings, allow designated FAU students to conduct an onsite assessment, and provide specific data on the following topics: waste generation volumes and costs; purchasing records for supplies and some services; energy consumption and costs; water consumption and costs; and seasonal occupancy rates. We further understand that all of the aforementioned data will be kept confidential and used for the sole purpose of examining the quantitative aspects of our current environmental programs and their future enhancements.

We look forward to working with FAU and FDEP on this exciting project and are anxious to take the next steps in forwarding the program.

Yours truly,

A.J. Jabbour
General Manager

620 East Las Olas Boulevard • Fort Lauderdale, FL 33301 • 1-800-325-3280 • (954) 467-0671 • Fax (954) 462-2148 • www.RiversideHotel.com

References

Abrams, D.W. (1986). Low Energy Cooling, Van Nostrand Rheinhold, New York.

Abt Associates, Inc. (2001). “A Method for Quantifying Environmental Indicators of Selected Leisure Activities in the United States.” EPA-231-R-00-001, US Environmental Protection Agency, Washington, DC

Alexander, S. (2002). “Green Hotels: Opportunities and Resources for Success.” Zero Waste Alliance. Edited by C.Kennedy. Portland, OR.

APPA and ASBDC (2003). Energy Efficiency Pays: A Guide for the Small Business Owner. American Public Power Association and Association of Small Business Development Centers.

ASHRAE (1994). ASHRAE Refrigeration Handbook. American Society of Heating, Refrigerating and Air-Conditioning Engineers. Cited in Bose, James E., Marvin D. Smith, and Jeffrey D. Spitler. 1998. Icemakers, Coolers and Freezers, and GX. Geothermal Heat Pump Consortium Inc. Washington, D.C.

Baldinger, P. (2006). Energy and Sustainable Tourism: Energy Supply and Use in Off-Grid Ecotourism Facilities. USAID EGAT/Energy Team.

Barron, T., C. Berg, and L. Bookman (1999). How to Select and Use Safe Janitorial Chemicals. Pollution Prevention Incentives For States, U.S. EPA Region IX, California EPA, County of Santa Clara.

Burger R. (2005) State’s green lodging programs and hotels’ eco-friendly practices plant the seeds for greener bottom lines. *The Rooms Chronicles*, 13(6): 1-3.

Burkett, G. (2007). Business Energy Incentives 2007. Presentation March 13, 2007. Progress Energy, Lake Buena Vista, FL.

CERES (2006). Green Hotel Initiative. Investors and Environmentalists for Sustainable Prosperity. http://www.ceres.org/industryprograms/ghi.php

Cummings, J.B. (2004). Some Thoughts on the Prevention of Moisture and Mold Problems in Lodging Buildings. Florida Solar Energy Center. Florida Green Lodging Certification Program Assessor Training, Deerfield Beach, FL, July 14, 2004.

Davies, T. and Cahill, S. (2000). “Environmental Implications of the Tourism Industry.“ Discussion Paper 00-14. Resources for the Future, Washington, DC.

Davis, M.L. and S.J. Masten (2004). Principles of Environmental Engineering and Science. McGraw Hill, St. Louis, MO.

Defranco, A.L. and Weatherspoon, K.E. (1996). “Go green: An environmental checklist for the lodging industry.” *Cornell Hotel and Restaurant Administration Quarterly,* 37(6): 84.

DuChene, B.J. (2005). Green Lodging Indoor Air Quality. MACTEC Engineering and Consulting, Inc. Florida Green Lodging Certification Workshop, Panama City Beach, FL. January 26, 2005.

Energy Information Administration (1999). Commercial Buildings Energy Consumption Survey (CBECS) in 1995. Release date: July 1998.

Energy Information Administration (2003). Electricity Consumption by Size and Type of Lodging Building: 1999 Building Data. Release date: January 21, 2003. http://www.eia.doe.gov/emeu/cbecs/pba99/lodging/lodgingconstable.html

Energy Information Administration (2006). Emissions from Energy Consumption for Electricity Production and Useful Thermal Output at Combined-Heat-and-Power Plants. Electric Power Annual with Data for 2005, Report Released: October 4, 2006.

Energy Information Administration (2007). Annual Energy Outlook 2007 with Projections to 2030. Year-by-Year Reference Case Tables 2004-2030. Report #DOE:EIA-0383. Release date: February 2007. http://www.eia.doe.gov/oiaf/aeo/index.html

Environment Canada (2004). Comprehensive Energy Use Database Tables. Accommodation and Food Services Secondary Energy Use and GHG Emissions by End-Use. Office of Energy Efficiency. http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_com_ca.cfm

E Source (2004). Managing Energy Costs in Full-Service Hotels. E Source Companies LLC.

Fecteau, V. (2005). The Second Commercial and Institutional Consumption of Energy Survey: Based on 2004 Data from Statistics Canada. Office of Energy Efficiency (OEE) of Natural Resources Canada, Ottawa, Ontario.

FEES and Cook, G. (1994). Energy Efficiency and Environmental News: Indoor Air Quality. Florida Energy Extension Service. Institute of Food and Agricultural Sciences, University of Florida. July 1994.

Fisk, W.J. (2000). Estimates of potential nationwide productivity and health benefits from better indoor environments: an update. Indoor Air Quality Handbook. Editors J. Spengler, J.M. Samet, and J.F. McCarthy, McGraw Hill, New York.

Florida Power and Light Company (2004). Energy Efficient Practices for Hotels/Motels. Presented by David Bates. Florida Green Lodging Certification Workshop, Deerfield Beach, FL. July 14, 2004.

Geiger, R. (1957). The Climate near the Ground, Harvard University Press, Boston, MA.

Green, K. (2007). “Cooking Up Some Energy Conservation.” Walt Disney World Company. Presented at the Energy Conservation Workshop for the Hospitality Industry, Lake Buena Vista, FL. March 13, 2007.

Harlos, D.P. (2006). Health effects from the Great Indoors on Guests and Employees. Advantek Consulting, Inc. Improving Air Quality in Hotels and Public Buildings in Florida. Tampa, FL, May 3, 2006

Helfritch, C. (2006). Personal communication, May 23, 2006. Director of Utilities, City of Boca Raton. Data provided via excel spreadsheet.

Hemmila, Donna (1988). “Hotels turn over new leaf with eco-friendly practices.” South Florida Business Journal (Broward County), July 24, 1998, 18(49):19A.

Hetes, R., Moore, M., and Northeim, C. (1995). Project Summary: Office Equipment: Design, Indoor Air Emissions, and Pollution Prevention Opportunities. USEPA Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, EPA/600/SR-95/045.

Hinton, C., Jenkins, D., Keating, A., Roeder, C. (2004). Green Lodging Best Management Practices CD On-Line. UF/TREEO, FDEP, USEPA. http://www.treeo.ufl.edu/greenlodging/content/_h2o.htm

IH&RA (1995). Environmental Good Practice in Hotels: Case studies from the International Hotel & Restaurant Association Environmental Award. United Nations Environment Programme, Industry and Environment.

IOM (2004). Damp Indoor Spaces and Health. Institute of Medicine of the National Academies. The National Academies Press, Washington, DC.

Meeroff D.E. and F. Bloetscher (2006). “Resolving Biofilms in Buildings and Compounds,” FS/AWWA 2006 Fall Conference, Renaissance Orlando Resort at Seaworld, Orlando, FL. November 29, 2006.

Michigan Department of Labor and Economic Growth (2006). “How Efficient is Your Facility?” Green Lodging News, March 2006 edition.

Miller, K. (1994). Energy Efficiency & Environmental News: Hospitality Industry. Florida Energy Extension Service, Cooperative Extension Service, Institute of Food and Agricultural Sciences.

Milton, D.K., Glencross, P.M., and Walters, M.D. (2000). Risk of sick leave associated with outdoor air supply rate, humidification, and occupant complaints. *Indoor Air*, 10(4): 212-221.

Moore, K. (2005). Florida Green Lodging Certification Program Brochure. Florida Department of Environmental Protection. Tallahassee, FL.

NCDENR (1998). “Hotel/Motel Waste Reduction.” North Carolina Department of Environmental and Natural Resources, Division of Pollution Prevention and Environmental Assistance. DPPEA-98-16.

NCDENR (1999). “Water Efficiency: Water Management Options-Kitchen and Food Preparation.” North Carolina Department of Environmental and Natural Resources, Division of Pollution Prevention and Environmental Assistance. DPPEA-FY99-36.

Newsome, K. (2006). Indoor Air Pollution. Indoor Environmental Consultants, LLC. Improving Air Quality in Hotels and Public Buildings in Florida. Tampa, FL, May 3, 2006

NHDES (2001). “Staying Green: a guide to waste management for the lodging industry in New Hampshire. New Hampshire Department of Environmental Services, NH DES-R-WMD-05, Concord, NH.

PA Consulting Group (2001). Toolkit Series for Small Hotels: Energy Conservation. USAID Environmental Audits for Sustainable Tourism (EAST) Project.

Ponikau, J.U. (1999). The Diagnosis and Incidence of Allergic Fungal Sinusitis. Mayo Clin. Proc., 74:877-884.

Ohlsen, M. (2007). State and Federal Energy Assistance Programs. Florida Energy Office, Department of Environmental Protection, Presented at the Energy Conservation Workshop for the Hospitality Industry, Lake Buena Vista, FL. March 13, 2007.

O’Neill & Siegelbaum and The RICE Group (2002). Hotel Water Conservation: A Seattle Demonstration. Prepared for Seattle Public Utilities Resource Conservation Section, Seattle, WA.

Parker, D.S., S.F. Barkazsi Jr., and J.K. Sonne (1996). Measured impacts of air condenser shading. The Tenth Symposium on Improving Building Systems in Hot and Humid Climates, Texas A & M University, Fort Worth, TX, May 13-14, 1996.

Richards, A.L., Hyams, K.C., Watts, D.M., Rozmajzl, P.J., Woody, J.N., and Merrell, B.R. (1993). Respiratory disease among military personnel in Saudi Arabia during Operation Desert Shield. *American Journal of Public Health*, 83(9):1326-1329.

Riggle, D. (1992). “Resorting to Recycling: Hotels Join the Parade.” *BioCycle* 33(10):37 – 39.

Rosenwald, M.S. (2006). Marriott Hotels Ban Smoking In Rooms. *Washington Post*. July 20, 2006; Page A01.

Siegelbaum, H. (2005). Lodging and Food Arts Best Management Practices: A Practical Guide for Puget Sound. People for Puget Sound, Seattle, WA.

Sierra Environmental Technologies, Inc. (2006). Healthier Solutions for Indoor Environments. Tampa, May 2006.

Sindoni, S. (2006). See Energy in a New Light. Florida Green Lodging Certification Workshop, St. Augustine, FL. November 2, 2006.

USEPA (1990). A building owners guide to operations and maintenance programs for asbestos containing-materials. United States Environmental Protection Agency, EPA/400-K-90-100, Washington, DC.

Vickers, A. (2001). Handbook of Water Use and Conservation. WaterPlow Press, Amhurst, MA.

VisitFlorida (2006). Florida’s Key Tourism Indicators. Data obtained from Individual Florida airports; Travel Industry Association, Travelscope data, U.S. Department of Commerce, ITA, Tourism Industries, and Statistics Canada. http://www.visitflorida.org/index.cfm?fla=web&webpageid=406&mid=660

West, M.K. (2006). Cool, comfortable, and productive. Advantek Consulting, Inc. Improving Air Quality in Hotels and Public Buildings in Florida. Tampa, FL, May 3, 2006.

West, W.W. (2006) Hotel and Motel Water Conservation, Florida Green Lodging Workshop, Best Western-The Westshore Hotel, May 2, 2006.

Westphalen, D., R.A. Zogg, A.F. Varone, and M.A. Foran (1996). Energy Savings Potential for Commercial Refrigeration Equipment. Final Report Prepared by Arthur D. Little, Inc. for Building Equipment Division, Office of Building Technologies, U.S. Department of Energy. Reference #. 46230-00.

White, B.M. (2004). Hotel & Motel Water Hotel & Motel Water Conservation: Saving Water by Implementing Conservation Measures. Tampa Water Department, August 3, 2004.

Yon, M.J. (2005). Press Release: Partnership Agreement between Florida Department of Environmental Protection and ProTeam Incorporated. Florida Department of Environmental Protection, Division of Waste Management. Tallahassee, FL.

USEPA and USCPSC (1995). The Inside Story: A Guide to Indoor Air Quality. U.S. Environmental Protection Agency and the United States Consumer Product Safety Commission, Office of Radiation and Indoor Air (6604J). EPA Document # 402-K-93-007, April 1995.

USEPA (2004). ENERGY STAR® Building Upgrade Manual. Air and Radiation 6202J. Washington, DC. December, 2004.

USGBC (2005). LEED®-NC Green Building Rating System for New Construction and Major Renovations, Version 2.2. United States Green Building Council. Washington, DC.

Upton, B. (2007). Green Interior Design: Myths vs. Facts. EcoDecor, Inc., Build Green, Save Green Conference, Boca Raton, FL. March 7, 2007.