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Water and Energy Conservation for Fideicomiso

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Abstract

The Conservation Trust of Puerto Rico owns two historic buildings that are not energy and water efficient. Desiring to be a role model of energy and water conservation, the Trust wants to renovate them. The goal of this project was to recommend cost-effective renovations to increase energy and water efficiency while preserving each building's historic character. Through observations, archival research and interviews, we determined the potential areas for energy and water conservation and methods for educating the public.

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Executive Summary

With the increasing global consensus on the need to preserve environmental and natural resources, buildings—major consumers of energy and water and key contributors to carbon-dioxide emissions—have become more and more crucial as a focus for energy and water conservation and environmental protection. The sponsor of this project, the Conservation Trust of Puerto Rico, aims to be a role model of energy and water efficiency. However, it owns two historic buildings in Old San Juan, the Banco Español and Casa Ramón Power, that are not energy and water efficient. To conserve energy and water used in the two buildings and demonstrate good habits of conserving water and energy to the general public, the Trust wants to renovate these two buildings. Once renovated, the buildings would reduce carbon-dioxide emissions by decreasing the amount of energy needed to operate them. Moreover, water reuse and reduction in these buildings would allow potable water to be used more conservatively.

The goal of this project was to recommend cost-effective methods to renovate the Trust's two buildings in order to improve their water and energy efficiency, while preserving the buildings' historic integrity. To achieve this goal, we developed five objectives: determine the baseline of energy and water consumption in the Trust's two buildings; identify different types of energy consumption-reducing devices and find potential alternative energy sources suitable for old buildings in San Juan; determine water reducing or reusing methods suitable for old buildings in San Juan; suggest energy and water conserving building renovations for Banco Español and Casa Ramón Power; and suggest areas of education on energy and water conservation for the Trust's staff members and methods for educating the public on these topics.

We found two main sources of alternative energy for these buildings. Solar energy is a renewable source of energy that makes use of sunlight. One method to turn this power into electricity is by using photovoltaic cells that could be placed on the roofs of the Trust's buildings (Solar Power, 2012). Wind energy takes advantage of another natural resource, turning wind power into electricity with the use of windmills or turbines. Installation of energy- efficient light bulbs, office equipment, air conditioners, sensors, and other appliances can also help to reduce energy consumption. Furthermore, it is important to ensure the buildings are properly insulated so that air conditioning is more efficient.

We identified several possible methods that can reduce the amount of potable water used in a building. Greywater is soapy water from washing machines, showers and hand sinks (Al-Jayyousi, 2003). The most common uses for greywater after treatment are irrigation and toilet flushing. More contaminated than greywater is wastewater, which exits toilets and kitchen sinks (Chu, 2004). After treatment, wastewater is used for irrigation and some industrial purposes. Rainwater can be collected and purified into potable water instead of draining into sewage systems or directly into bodies of water (Kinkade-Levario, 2007). Additional uses for rainwater include irrigation and toilet

flushing. Some options to reduce potable water use include installing equipment such as toilets and sinks that use less water than traditional models.

In order to identify which of the various energy and water conservation methods would be most applicable for the Trust's buildings, we first determined their current energy and water consumption. We assessed the two buildings currently in use, Casa Ramón Power and the building at 201 Tetuán Street. We examined the total energy and water use and patterns by examining the previous utility bills. We inventoried the number and types of computers, lights, toilets, faucets, air conditioners and other appliances, with electricity and water usage estimated. Additionally, we interviewed the staff working in the buildings to understand their habits and knowledge of energy and water conservation. Understanding the energy and water baseline allowed us to make recommendations about how to make improvements.

We examined similar renovations in the Old San Juan district to understand the techniques that have been adopted and their effects on energy and water efficiency. Through Aireko Enterprises we were able to learn about additional conservation methods and witness firsthand energy and water conservation methods being used in an Old San Juan building. The Cuartel de Ballajá renovation project in Old San Juan demonstrated the potential savings that solar panels can offer in Puerto Rico. In fact, by investing the initial capital for a large-scale renovation to improve efficiency, most organizations will find that the renovations can pay for themselves in a short period of time. Aireko Enterprises predicts that their clients have a return on investment of about seven years.

To identify which methods would be most feasible and appropriate for the Trust, we used a simplified cost-benefit analysis to compare solar and wind power. We estimated the cost of renovation and the potential savings.

Lastly, in order to aid the Trust to become a green role model, we decided that it must start at home. Through our archival research and interviews with the Trust's staff, we analyzed the habits of the Trust staff that might lead to low efficiency in energy and water use and resources. To educate the public, we asked professionals how to promote the proposed "green" renovations. We also interviewed a member of the Trust to gain knowledge of the work the Trust has already done to educate the public.

Based on our analysis, we were able to draw conclusions and provide the recommendations below:

- Install an efficient mechanical system in Casa Ramón Power and a Building Monitoring System (BMS) in Banco Español to control the lighting and cooling systems;
- Change the lighting system from central control to individual room controls or use sensors to monitor occupied and unoccupied spaces;
- Use compact fluorescent light (CFL) or light-emitting diode(LED) light bulbs;

- Install solar panels and/or wind turbines;
- Update bathroom fixtures with more water efficient models;
- Install a small-scale greywater system connecting bathroom sinks with toilets;
- Install a rainwater harvesting system;
- Change the staff's habits, such as turning off the lights, computers and monitors while away from their desks, reduce the printers-to-users ratio;
- Adopt ENERGY STAR's energy and water management strategy and use its online tool to monitor their energy and water usage;
- Exhibit the energy and water conservation renovations and their impacts both in the exhibition room and online to educate the public.

Our recommendations for potential building improvements, based on an analysis of current conditions of energy and water consumption, interviews and background research, will aid the Trust in making its office buildings more energy and water efficient and user friendly. We hope, furthermore, that our recommendations regarding education will help the Trust to better manage their buildings and promote its work to the general public so that the Trust will not be alone in making such renovations.

1 Introduction

The United States is very dependent upon clean, potable water for drinking, showering, cooking, and various other activities; and non-renewable resources, such as fossil fuels, for energy. In 2010, fossil fuels provided over eighy percent of the total energy consumed in the U.S. (U.S. Energy Information Administration, 2011). High energy costs, increasing amounts of carbon-dioxide emissions and the threat of depleting natural resources all contribute to the increasing desire for energy conservation in individuals and organizations. Potable water is a natural resource that is becoming scarcer as the world's population grows. While water covers most of the earth, only three percent is fresh water, of which humans can use approximately one percent (Perlman, 2011). With more people occupying the planet, water will need to be conserved to assure everyone has enough to survive. Nowadays, both residential and commercial buildings contribute to a large percentage of energy and water usage. For example, in 2008, buildings in the U.S. consumed more than seventy percent of the total electricity and over ten percent of the potable water across the nation (U.S. Energy Information Administration, 2008). Therefore, increasing the efficiency of water and energy usage in buildings would go a long way towards conserving natural resources and solving environmental problems.

People can increase the water and energy efficiency of a building by adopting alternative energy resources, replacing outdated appliances and devices, and changing bad habits that waste electricity and water. The sponsor of this project, the Conservation Trust of Puerto Rico, is a private, non-profit organization that aims to preserve the environment and natural resources in Puerto Rico. The Trust strives to be a role model in environmental protection and energy and water conservation through multiple strategies, including adopting techniques to lower the water and energy consumption in their own buildings. However, two historic buildings the Trust currently owns in Old San Juan, Puerto Rico, are not environmentally friendly. Since both buildings are outdated, their efficiency in energy and water use is particularly poor. One building, Casa Ramón Power, was renovated in 1996. The other building, Banco Español, is not structurally sound and is overdue for a complete renovation. Both buildings are not energy and water efficient according to current standards.

Current research in the field of energy and water conservation focuses on reducing consumption of both and recycling as much water as possible. ENERGY STAR (2012a) reports on the energy usage of various products, such as light bulbs and air conditioners, to aid homeowners and building designers in choosing more energy efficient options. Researchers have developed technologies that harness energy from the sun and wind to reduce the amount of electrical energy coming from fossil fuel powered plants (Solar Power, 2012; Loepp et al, 2009). Technologies exist for capturing and using rainwater and stormwater, as well as water from washing machines, sinks, showers and tubs, for toilet flushing and irrigation (Al-Jayyousi, 2003; Kinkade-Levario, 2007). Furthermore, when comparing the effect of building renovation and reconstruction on environment, Frey et al (2011) found that renovation of buildings is better for the environment than demolition and reconstruction.

All of the previous research provides insights into how to use new, environmentally efficient technologies in designing new buildings and renovating existing buildings. However, no research has focused on the Trust's two outdated buildings in Old San Juan, Puerto Rico, where their unique historic atmosphere must be preserved. It is unclear which methods of energy and water conservation will produce the best results and be the most economically feasible for the Trust. As the Trust wants to be a role model for being energy and water efficient, they are very committed to discovering the best ways to make their buildings more environmentally friendly.

The goal of this project was to provide renovation recommendations for the two old buildings currently owned by the Trust in Old San Juan in order to improve their water and energy efficiency while preserving their historic integrity. To aid our sponsor in achieving their conservation goals, we had developed five objectives: determine baseline of energy and water consumption in the Trust's two buildings; identify different types of energy consumption reducing devices and find potential alternative energy sources suitable for old buildings in San Juan; determine water reducing or reusing methods suitable for old buildings in San Juan; provide suggestions for building renovations; and suggest methods for educating on energy and water conservation for the Trust's staff members and the public. We accomplished these objectives by auditing the Trusts' buildings, performing archival research, interviewing engineers, architects and occupants of the buildings, and determining the feasibility of the technologies for Casa Ramón Power and Banco Español through a cost benefit comparison. We gained understanding of the baseline of the energy and water use in the two buildings from analysis of previous utility bills as well as interviews with Trust's staff. We also identify potential renovation methods by research and interviewing the professionals. Based on the collected data, we identified that wind and solar powers would be alternative energy sources for both buildings; greywater reuse and rainwater harvesting would be beneficial for the Trust to conserve water. We also presented other ways for the Trust to renovate its buildings and an effective strategy to manage the water and energy use in the building. Our recommendations will aid the Trust in doing its small part in sustaining the environment. More importantly, the actions that the Trust takes will be proof of concept and encourage the general public to follow suit.

2 Background

The Conservation Trust of Puerto Rico currently owns two old buildings in Old San Juan that need renovations to improve energy and water efficiency while preserving their historic integrity. The Trust is seeking recommendations on conservation methods and alternative sources of energy and water. In this chapter, we will identify the existing guidelines for "green" buildings, the most common methods for energy and water conservation in buildings, the current energy and water usage patterns in Puerto Rico's buildings in general, the key guidelines for historic preservation in Old San Juan and the existing gaps in the analysis of historic building renovation for energy and water conservation.

2.1 Energy and Water Conservation

Since fresh water and energy resources are scarce, the corresponding conservation actions have become increasingly important among all the urgent environmental issues. Currently, fossil fuels remain the largest primary energy source (U.S. Energy Information Administration, 2011). Fossil fuel usage needs to be reduced because not only are we depleting crude oil, coal and gas irreversibly, but also the effect of greenhouse gas emissions, caused by using fossil fuels, is detrimental to the earth's atmosphere. Fresh water is unevenly distributed on earth, so we need methods to improve its consumption efficiency, especially in arid or densely populated areas.

Energy and water consumption in buildings, both residential and commercial, impacts the environment. In 2008, buildings in the U.S. consumed 40% of the primary energy, 72% of electricity and 13.6% of potable water, while contributing 39% of the total carbon-dioxide emissions (Energy Information Administration, 2008). In fact, great efforts have been put into analyzing the characteristics of energy and water usage in buildings, as well as various methods of improving their efficiency. Research results showed that "green" buildings, which have been constructed or renovated to be environmental friendly, can effectively reduce 24%-50% of energy use (Kats, 2003; Turner & Cathy, 2008), 40% of water use (Kats, 2003), 33%-39% of carbon-dioxide emissions (Kats, 2003; GSA Public Buildings Service, 2008), and 70% of the solid waste over ordinary buildings (Kats, 2003). Therefore, energy and water conservation in buildings has become one of the most effective ways to protect the environment and preserve natural resources.

Energy codes and rating systems used both internationally and domestically in the U.S. should be considered during any renovation project in Puerto Rico. In the following section we will introduce three sets of criteria: the International Energy Conservation Code (IECC), the Leadership in Energy and Environmental Design (LEED) rating system and the National Energy Performance Rating System created by Environmental Protection Agency (EPA).

2.1.1 International Energy Conservation Code

The International Energy Conservation Code (IECC), first published by the International Code Council (ICC) (2012) in 1998, is a model code that regulates minimum energy conservation requirements for new and existing buildings. Many countries use the code, including the United States, Canada, Australia and China (U.S. Department of Energy, 2011). The IECC contains two separate sets of provisions-one for commercial buildings and one for residential buildings. Each set of provisions is applied separately to buildings within its scope. Written in regulatory, enforceable language and specifying how buildings must be constructed or maintained, the IECC addresses all aspects of energy uses in both commercial and residential construction, including heating and ventilating, lighting, water heating, and power usage for appliances and building systems.

The ICC (2012) developed guidelines with consideration to climate differences among regions. Zone 1 in the U.S., which includes Hawaii, Puerto Rico, and a small portion of Florida, is representative of moist and very hot weather locations. Specifications for Zone 1 buildings differ from those of other zones mainly in the followings details: ceiling, wood frame wall, mass wall, basement wall, slab, crawlspace wall, fenestration, skylight, etc. The separation of criteria based upon climate regions is critical in applying appropriate and effective energy conservation methods to buildings in different regions.

2.1.2 Leadership in Energy and Environmental Design (LEED) Rating System

Created by the United States Green Building Council (USGBC) (2011) in 2000, the LEED rating system sets a baseline for measuring building energy performance and meeting sustainability goals. Through 2011, 58 countries have LEED initiatives, 45 states across the U.S. have adopted LEED standards, and 34 state governments, including Puerto Rico, have participated in the program.

LEED rates the energy performance of new or renovated construction on 1–110 point scale in the following six major aspects: "sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality and innovation in design" (USGBC, 2009, p. 2). Regarding the methods of achieving higher energy efficiency, USGBC identifies several ways such as insulating the building to resist cooling losses, making use of shaded areas for cooling, establishing energy performance targets for the residences, building up feedback systems for energy monitoring, providing educational programs for the community and creating motivation for residents to conserve energy and water. We will determine if the above methods are applicable in Puerto Rico.

The LEED rating system contrasts with the IECC in that the IECC functions as a design document, providing a set of basic requirements for a design prior to construction, while the LEED has sets of standards denoting different levels of utilizing green measures, assessing the building's actual performance rather than intentions (LEED for Homes Illinois, 2012).

2.1.3 EPA's National Energy Performance Rating System

Instead of providing baselines in building design, construction and renovation, EPA's National Energy Performance Rating System focuses more on management of energy and water used in existing buildings (ENERGY STAR, 2012). In 1999, the U.S. Environmental Protection Agency introduced the rating system to the public in response to the demand for energy saving guidance from the partners of the ENERGY STAR program (Reed, 2002). The ENERGY STAR program is a voluntary labeling program originally created by EPA in early 1992 in an attempt to identify and promote energy-efficient products to reduce greenhouse gas emissions (Climate Institute, 2010). The rating system is an online tool that helps owners or managers of the buildings track and assess energy and water consumption within individual buildings as well as across the entire building portfolio (ENERGY STAR, 2012). It rates a building's energy performance on a scale of 1–100 relative to similar buildings nationwide by analyzing and comparing the data of the building manually inputted by its owner or manager, such as the size, location, number of occupants, number of desktops and laptops, etc.. Buildings with superior energy performance are eligible to apply for an ENERGY STAR label, a symbol of being "green." For 2010 alone, as a group the ENERGY STAR qualifying buildings saved $7.1 billion dollars and avoided 81.2 MMT of carbon-dioxide emissions (Environmental Protection Agency, 2011).

In addition to generating a rating score, the ENERGY STAR (2012) rating system also allows its users to estimate their buildings' carbon footprints and, more importantly, to track energy and water use trends as compared with the costs of these resources. With its built-in financial tool, users can compare cost savings across building portfolios while calculating cost savings for a specific energy improvement project, quickly and clearly obtaining figures showing cumulative investments in facility upgrades and annual energy costs. Therefore, it is a very useful system for energy and water efficiency improvement projects.

2.2 Energy Saving Methods and Devices

Energy conservation has become a popular goal as people realize that fossil fuels and non-renewable resources are growing sparse and costly (Patrick, Fardo, Richardson, & Patrick, 2007). Buildings usually pull in power from a power plant, which can vary from nuclear power to coal power, etc. Most vehicles run on some form of petroleum-based fuel, but many alternate power sources have emerged in recent years. Mechanical devices receive electricity from a variety of sources, including batteries, home circuits, and others. Because the world population is growing at a rapid rate, many of these resources, not being renewable, could run out within the next few decades.

Many countries, including the United States, have already started to prepare for the depletion of these resources by investing federal money into research on energy conserving devices and appliances. For example, the U.S. set up ENERGY STAR to regulate a database that helps the public conserve energy and save money (ENERGY STAR, 2012a). ENERGY STAR and other similar organizations research and recommend products and techniques that are environmentally friendly. The electrical and mechanical systems of a building can greatly affect how much energy is consumed (Terry, 2008). If one system is renovated and the other is not, the savings will be cut into due to the inefficiency of the non-renovated system. In an interview with senior project manager, Steve Magill of Griffin Electric (personal communication, February 11, 2012), this point was constantly stressed. Mr. Magill noted that for the best results and maximum energy efficiency, all the energy systems of an older building should be renovated and not just individual ones. He explained that mechanical and electrical renovations go hand in hand, and strategically examined updates in these complementary systems can result in huge monetary savings. By updating to new, energy-efficient structures, a building can cut energy use and costs.

Alternative energies, like wind and solar power, can also play a giant part in preserving non-renewable resources, such as oil and coal (Patrick, Fardo, Richardson, & Patrick, 2007). Scientists are intensively researching these technologies, and as they make progress, buildings can become more self-sufficient. Further examination into energy saving methods and devices and alternative sources of energy will help to preserve the Earth as long as possible, while at the same time, reduce the amount of money people spend on rising energy costs.

2.2.1 Energy-Saving Products

There are many energy-saving methods and devices that are cheap and effective. One option for saving energy includes the purchase and installation of green electronic products, such as energy efficient light bulbs, electronics, and mechanical systems. ENERGY STAR (2012a) stands out as one of the most trusted sources for information on energy efficiency. The U.S. Environmental Protection Agency and the U.S. Department of Energy administer the program in an effort to help Americans save energy and protect the environment. Since the program started in 1992, ENERGY STAR has joined with over 20,000 businesses and associations and taken the initiative of reviewing and rating electronics, appliances, building methods, and more. The organization also identifies products that will save people money in energy costs. ENERGY STAR reports that it assisted Americans in saving "enough energy in 2010 alone to avoid greenhouse gas emissions equivalent to those from 33 million cars - all while saving nearly $18 billion on their utility bills" (para. 2). Additionally, ENERGY STAR states that energy efficient households, on average, save about a third of their money on a typical energy bill. If ENERGY STAR reviews a product positively, it means that the product will consume less energy, last longer, and/or be recyclable after its operation.

2.2.2 Light Bulbs

The electric infrastructure of a building and how its occupants practice energy saving methods can greatly affect energy consumption. Some simple ways to conserve electricity include shutting off the lights when leaving a room and unplugging devices when they are not in use (ENERGY STAR, 2012c). Many factors go into planning the lighting of a room. Windows are a significant part of any room, since they provide free, natural light; a home, nevertheless, requires electric light once the sun has gone down. Important features of a green light bulb include appearance, brightness, and lifespan. Appearance is the simplest quality to determine for a buyer. One must determine the color of light they want, the shape of the bulb, and the style.

The brightness of a bulb is one of the most important qualities of a bulb (ENERGY STAR, 2012c). Many people believe that the higher the wattage, the brighter the bulb. While this concept may have been true when only incandescent bulbs were used, the brightness of a light actually depends on the amount of lumens a bulb produces. A lower watt bulb with a high lumens output emits more brightness than a higher watt bulb with a low lumens output. The ENERGY STAR website mentions that a "Lighting Facts label [is] required by law as of January 1, 2012" (para. 4). This will help consumers realize a bulb's efficiency when purchasing it. ENERGY STAR also explains that the U.S. government urges companies to attempt to lower the wattage of their products, while keeping the same lumens level. The actual aesthetics of a bulb's light is directly related to the brightness. Steve Magill (personal communication, February 11, 2012) made a point that "people are used to certain comfort levels of colors of light," and usually desire a color similar to the sun's light. Newer types of bulbs that use different technologies have a tough time matching the color of natural light, unlike traditional fixtures. One also has to consider the lifespan of a light bulb when selecting a type. With a longer bulb life, the consumer ends up spending less money to buy replacement bulbs. All of the bulb qualities depend on the type, and there are three main types: incandescent, compact fluorescent (CFL), and light-emitting diode (LED).

Howard, Brinsky, and Leitman (2011) explain that "the basic incandescent bulb hasn't changed much in the 120 years since Thomas Edison invented a profitable model" (p. 33). This model consists of a glass bulb filled with a gas, usually nitrogen or argon, and wires leading up to a filament, which produces light when electricity runs through it (pp. 36-37). If looking for low prices, incandescent bulbs are often the cheapest. These models have two key deficiencies, however: they usually have the shortest lifespan when compared with CFLs and LEDs, and they do not produce as many lumens per watt as their counterparts.

Shortly after Thomas Edison invented his incandescent light bulb, scientists began experimenting with other methods to create another type of bulb. The modern fluorescent bulb produces light by running electricity into a vacuum of mercury and inert gases (Howard et al, 2011, pp. 51-62). The electricity reacts with the vacuum's phosphor coating, which creates a glowing environment. For a long time, businesses only sold long, slender, cylindrical fluorescent bulbs. In the past 30 years, newer, small fluorescent bulbs have been developed to fit in most lamps and home fixtures; these are called compact fluorescent light bulbs, or CFLs. While some CFL bulbs may look similar to regular incandescents, the two types are quite different. The average incandescent bulb generates about 17 lumens per watt and lasts between 750 and 1,000 hours. A typical CFL ranges between 40 and 100 lumens per watt and has a lifetime of 6,000 to 15,000 hours. So, why has the world not shifted from incandescent to fluorescent lighting, comparable to how it moved from VHS tapes to DVDs? As with any product, CFLs have their drawbacks. Some examples of problems experienced with CFLs include low light quality, lifespans differing from those advertised, and taking too long to reach full brightness.

LED lights are basic lights that operate through a semiconductor diode (Howard et al, 2011, pp. 92-101). As with the other bulbs, the LED casing is filled with a specific gas that chemically reacts with the electrons to create luminosity. LEDs are often quite small and used in electronics for indicator lights; LED light bulbs are a newer concept. Through the integration of LEDs in casings the size of the regular incandescent bulbs, consumers can now use LED lights in their homes and businesses. The U.S. Department of Energy predicts that LED lights could potentially cut the amount of energy used in the U.S. by 50% and the total electricity used by 10%. One case from the work of Howard et al (p. 89) can exemplify the actual power of LED light bulbs as it observes an instance in November 2009, where over 2,000 11-watt incandescent light bulbs were replaced in the Reno Arch in Reno, NV. These replacements were not the usual incandescent bulbs, but instead, 2,076 2.5-watt LEDs. This change to the Arch's lights will save the city a total of $10,441 per year in lighting costs. Because LED technology is emerging, the cost of these bulbs is still higher than the average bulb. When compared with incandescent and CFLs, LEDs produce 50 and 90 lumens per watt and reportedly last an average of 50,000 hours.

2.2.3 Electric Lighting Controls

Lighting controls serve as an important feature to help consumers save money and energy. Many types of controlling devices exist, including dimming controls, on/off switches, and occupancy sensors (Nelson, 2010). Dimmers allow the user to adjust the level of lighting, meaning that they can turn down the power being consumed. This feature helps homeowners save money on both energy bills and light bulb replacements. The on/off switch is a self-explanatory device that every lighting system needs. To save money, users should turn off the lights when they are not needed or when they leave a room. To simplify this process, commercial and residential properties have turned to occupancy sensors. Occupancy sensors will automatically turn on a light when a person enters a room. They also maintain the lighting for as long as the room stays occupied and shut off the lights when they sense a room is no longer being used. In an extreme effort to display the importance of energy efficiency, Target replaced the electrical features of its refrigeration units in 500 stores across the U.S. (Schuellerman, 2010). By replacing the fluorescent lighting in over

55,000 refrigerated display cases with LED lights and occupancy sensors, Target reduced its energy consumption by over 60 percent.

Builders employ the use of three different types of occupancy sensors (Nelson, 2010). Passive infrared (PIR) sensors use infrared technology to sense when something passes its viewing area. Not just anything sets off a PIR, though; the infrared sensors only read heat releasing bodies. The second type of sensor is an ultrasonic sensor. It works by discharging a sound pattern, and when this pattern is interrupted by something moving, the lights will turn on. Lastly, the dual-technology occupancy sensor uses both of these tools to avoid errors. Since this sensor employs the use of both of the other sensors, it is larger and more costly.

2.2.4 Air Conditioning and Heating

Heating, ventilation, and air-conditioning (HVAC) systems that heat and cool a building can consume up to half the total energy used in that building (ENERGY STAR, 2010c). Outdated or malfunctioning units can cost a building owner thousands of dollars in utility costs. There are a few methods that can improve the efficiency of a building's HVAC system. Regular annual inspections of the infrastructure help to ensure the air-conditioning and heating systems run properly. An air filter fills up with particles quickly and should be replaced each month for optimal performance. Programmable thermostats help to put an HVAC system on a schedule. A user can set the system to shut down for periods of time during the week. For example, if one works a nine-to-five job, he or she can program the thermostat to turn the HVAC system off automatically during this time. One of the newer technologies that has become an important feature of any mechanical system is the variable frequency drive (VFD) (S. Magill, personal communication, February 11, 2012). These devices were specifically developed to conserve energy consumption by motors that run in plumbing, HVAC, and electrical systems. The VFD ensures that the motor is not wasting energy through over-consumption or inefficient running. There are numerous applications for VFDs. One can precisely control the speed of an air-conditioning motor, which can help cut costs in cooling. They are able to generate complete torque from a motor that is running at a low speed and can also save a large amount of energy, specifically in centrifugal pumps of a plumbing system and fans of an HVAC system.

Purdue University conducted a study that analyzed ways to reduce energy consumption of HVAC systems (Anonymous, 2006). A lot of times, energy usage increases during the day, with the highest spikes of usage mid-day when it is hottest outside. The study hypothesized that a pre-cooling method could help save energy in small commercial buildings, therefore saving owners money. The method they tested consisted of turning the air-conditioning system to a cooler setting than normally used in the morning. The scientists then proceeded to turn the A/C to a warmer setting than normally used at the hottest part of the day. Since the building has already been pre-cooled in the morning, it does not consume as much energy at temperature peak hours.

2.2.5 Window and Effective Solar Shading Methods

In office buildings and classrooms, effective solar shading devices can reduce solar heat gains and control the indoor illumination from daylight (Florida Solar Energy Center, 2007). Thus, they have become an important part of energy conservation for buildings.

There are four factors to be considered for a window: U-factor, Solar Heat Gain Coefficient, Visible Light Transmittance, and Air Leakage Rating (U.S. Department of Energy, 1997). U-factor, or U-value, is a measure of the rate of heat flow through a material. Window manufacturers and engineers commonly use the U-factor to describe the rate of non-solar heat loss or gain through a window or skylight. Lower window U-factors have better insulating values. Double-pane windows generally have lower U-factors than single pane windows. In addition to that, many manufacturers have incorporated two technologies aimed at decreasing U-factors: low-emittance (low-E) coatings and gas fills. A low-E coating is a microscopically thin, virtually invisible, metal or metallic oxide coating deposited on a glazing surface that can be applied to windows. "Gas fills" refers to the method of filling the space between window-panes with gases that insulate better than air. Furthermore, frames and spacers made of better insulating materials also lower a window's overall U-factors. In most climates, glazings with low-E and gas fills will be a choice that provides significant energy savings in a cost-effective product and the resultant total window U-factor should be below 0.4 for maximum energy savings. Solar Heat Gain Coefficient (SHGC) is a standard indicator of a window's shading ability. The higher the SHGC value, the better the shading effect of a window. Air Leakage Rating is a measure of the rate of infiltration around a window or skylight in the presence of a strong wind. The lower a window's air leakage rating, the better its airtightness is. Visible Transmittance is the percentage of visible light transmitted by a window or skylight. Nowadays, the National Fenestration Rating Council (NFRC) labels the four factors for windows sold in the market.

For better shading effect, in northern hemisphere, it is easy to protect south facing windows with a roof overhang for all but the lowest winter sun (Florida Solar Energy Center, 2007). For east- and west-facing windows, it is best to block the sun outside, before it reaches the glass, using trees, awnings, shutters, or other shading methods. North-facing windows hardly need any shading since the only time the sun impinges on them is early in the morning or late in the afternoon in summer, and glass reflects or walls on either side of the window block much of the radiation, due to the great angle of the sun incidence.

There are both exterior and interior shade options available for use on the windows (Florida Solar Energy Center, 2007). Exterior shading strategies include sun screens, slatted aluminum, trees, hood awnings, etc., as shown in Figure 1.

Interior shading strategies can be draperies, Venetian blinds, vertical blinds, roll up shades, etc. (Florida Solar Energy Center, 2007). They are more for aesthetics and privacy than for solar heat gain prevention, but they can be effective heat blockers when used properly. It is important

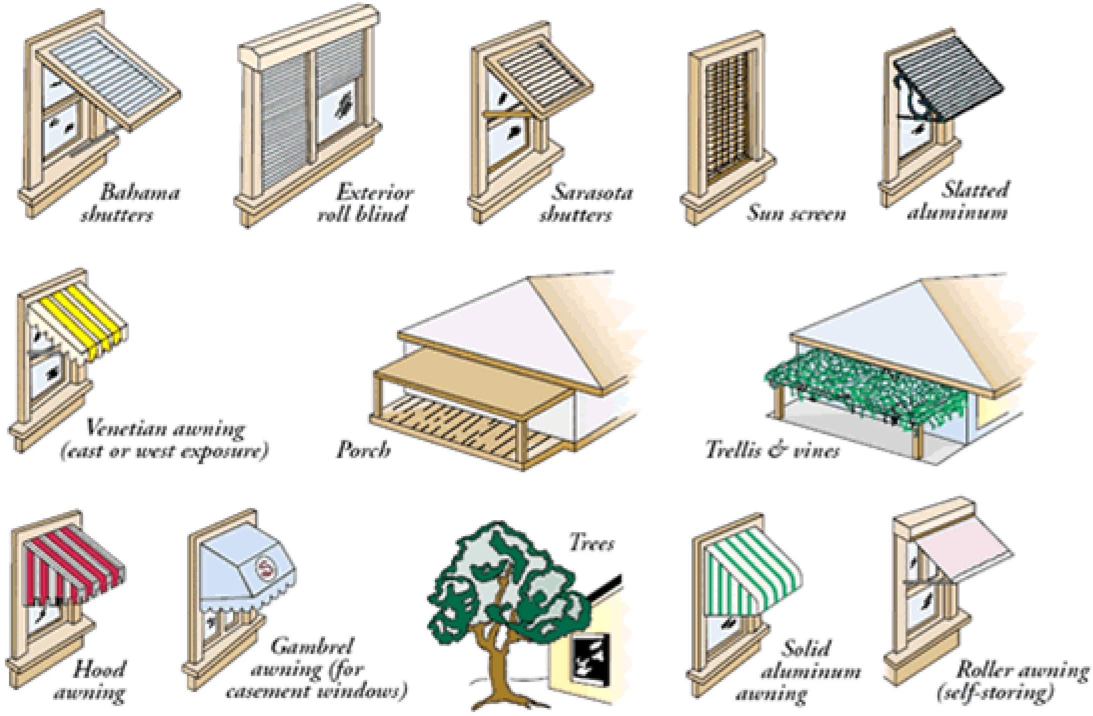

Figure 1: Exterior Window Shading Strategy. This figure illustrates different types of exterior window shading methods (Florida Solar Energy Center, 2007, para. 9).

to choose the shades with higher solar reflectance on the window-facing side. A shade can have any color and pattern for the room-side according to the different illumination requirements of the occupants, but the window-facing side should always be bright to reflect sunlight as much as possible. White or near-white is best.

2.2.6 Solar Energy

Solar energy can generate electricity through photovoltaic cells placed on the roofs of buildings (Solar Power, 2012). Technology in solar panels is advancing at an exponential rate, and as the price for these alternative energy devices drops, they are becoming more popular in both residential and commercial settings. The sun's energy is a free, renewable resource that has only recently been taken advantage of for electricity generation.

Several reasons exist that can explain the sudden spike in the popularity of solar panels. The research of scientists at technology companies has helped to develop the science that makes the panels work (Loepp & Griswold, 2009). As production methods become more efficient and panels are built from cheaper materials, the solar panel market has become more competitive. The governments in many countries offer incentives and rebates for those who invest in solar panels for their homes (Wilson, 2007). For example, Wilson explains that “the California Solar Initiative (CSI), the third-largest solar incentive program in the world, offers cash incentives on solar systems of up to $2.50 per watt” (para. 1). Residential and commercial buildings have all sorts of different roof styles and materials. Lumeta developed a panel that looks architecturally appealing and installs quickly and easily, which cuts costs drastically (Anonymous, 2008). Dow also released a new type of solar panel, called Powerhouse solar shingles. These devices function through very thin photovoltaic cells combined with a molded shingle design. Loepp et al (2009) explain that “because any roofing contractor can install these, consumers will save about 50 percent on installation costs” (para. 6). Also, the price for oil has been, for the most part, steadily rising as the resource is slowly used up. The technology industry, as a result, has taken the initiative to find cost-effective alternative energies (Takahashi, 2008).

Yet solar energy still has some major areas to improve. Without the government subsidies that often accompany solar panels, the technology would not be a cost-effective alternative energy (Beggs, 2009; S. Magill, personal communication, February 11, 2012). Even with the incentives, these devices are not cheap. Solar panels require regular maintenance to run efficiently, and the average panel has a lifespan of about twenty years. Consumers have to analyze the panels specific to their building before purchasing them to make sure that the incentives, energy-savings, and costs all even out over the panels’ life. Once a panel’s life has been exhausted, the device needs to be disposed of. People are beginning to realize that solar panels fall into an e-waste category that includes batteries and other non-biodegradable electronics that contain all sorts of toxic materials. Considering the twenty year lifespan and the skyrocketing popularity of solar panels, a proper disposal method for panels needs to be developed in order to counteract the potential waste disposal problem. Solar panel users also face the problem of storing electricity for use during the night and cloudy days (Wald, 2008). Batteries have the ability to store energy on a small scale, but currently available batteries cannot efficiently store large amounts. Buildings that may not be suitable for solar panel installation are trying to retrofit their roofs with panels. This addition can affect the building’s roof greatly and can sometimes lead to leaks, structural problems, and more. These kinds of buildings should consider other alternative energies that do not require extreme retrofitting.

2.2.7 Wind Energy

Wind energy is one of the cheapest forms of alternative energy (Thornton, 2011). Wind has been harvested all over the world for centuries. Beggs (2009) states in his work that “in 1750 it was estimated that there were 8,000 windmills in operation in the Netherlands, with a further 10,000 in Germany” (p. 88). In recent years, one can find many areas where giant wind turbines create a forest of propellers in the ocean or deserts, which power factories or whole communities. Towns that are off the grid have taken advantage of these large mechanisms, too, as an alternative to diesel generators (Fleck, 2008). Over the past decade, smaller, residential wind turbines have been introduced in the market (Clayton, 2008). The demand for small wind turbines is increasing rapidly, and as it does, many businesses are taking advantage of the opportunity early.

Wind turbines have many positive features, which have helped them gain popularity in the "green" movement (Saidur, Rahim, Islam, & Solangi, 2011). Unlike generators, wind turbines only release a small amount of carbon dioxide, meaning less greenhouse gas and less harm to the Earth's atmosphere. Wind energy can also decrease the consumption of water used in a town. Saidur et al (2011) found that nuclear and coal power plants consume water at a rate of 0.62 gal/kWh and 0.49 gal/kWh, respectively; wind turbines only consume water at a rate of 0.001 gal/kWh. Most small wind turbines are rated between two and ten kilowatts and can provide an amount of energy to the consumer (Clayton, 2008).

A small wind energy system can be used as a practical and economical source of electricity (Energy Savers, 2011). If the average electricity bills are above $150, a small wind turbine may be an efficient alternative that offers electricity savings of fifty to ninety percent. A turbine is fairly basic, and works best if the wind is constant in turning the turbine's blades. A rotor captures the kinetic energy and then converts it to rotary motion in order to drive the generator. All the basic parts of a small wind turbine can be seen below in Figure 2. Most turbines have overspeed-governing systems that limit the speed of the blades, which is important in an area where hurricanes are present. Also, many turbines are supported by a post that can be lowered in the case of ominous weather or have brakes that limit the speed of the blades.

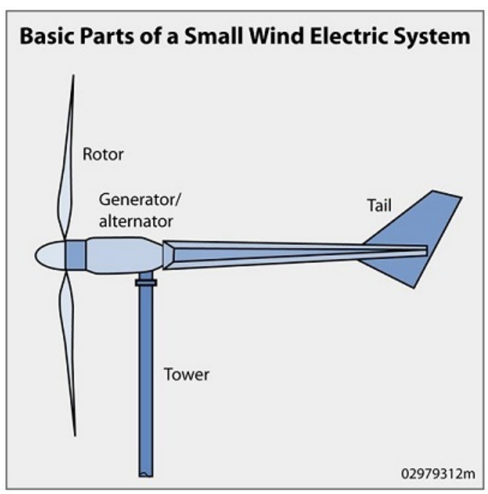

Figure 2: Basic parts of a Small Wind Electric System. This figure demonstrates a basic HAWT wind turbine (Energy Savers, 2011, para. 4).

There are two main types of small wind turbines, a horizontal axis or HAWT, and a vertical axis wind turbine, also known as VAWT (Polacios, 2010). The HAWTs are the standard for alternative power, and they consist of two or more blades that spin perpendicular to the wind. The HAWTs provide large amounts of energy, as the blades spin very fast. A VAWT is not the traditional wind turbine. It lies flat and spins parallel to the wind, and therefore has a major advantage, as it doesn't need to rotate to face the wind. These VAWTs can be the better alternative for residential areas cluttered with obstacles that disrupt airflow. VAWTs rotate at a third of the speed of HAWTs, so they also have limited amounts of noise and vibration. VAWTs are more stable and are less affected by violent weather.

As with most sources of energy, there are some drawbacks to wind power. Wind turbines are considered one of the most environmentally-friendly alternative energies, but birds and bats often fly into the rotors of turbines, getting themselves killed or injured (Saidur et al, 2011). Other animals may mistake the turbines as trees and settle near them or climb them, which can also lead to deaths or injuries. The source for alternative energies may not be constant; solar panels cannot generate electricity without the sun, and wind turbines are not effective if there is insufficient wind (Beggs, 2009). For this reason, turbines are most effective in coastal regions and in areas at higher latitudes, where wind blows consistently. Another major problem faced by individuals seeking small wind turbines is zoning laws (Clayton, 2008). Many cities and towns will prohibit the erection of wind turbines, claiming that they are unsightly to the community. The laws become even more stringent if buildings are historic ones. The rotors of wind turbines produce noise pollution, which can sometimes be heard up to 350 meters away. Clearly, the community's reaction usually consists of complaints related to the visual and audible impact. However, a residential-sized wind turbine doesn't produce a significant amount of noise under most wind conditions. As government officials become more educated on the subject, they are amending town regulations to allow the use of smaller wind powered devices.

2.3 Water Use and Management

Fresh water is a natural resource that is growing scarcer as the world population continues to grow. Puerto Rico uses 620 million gallons of fresh water per day; domestic and public supply use 82.88% of the fresh water (U.S. Geological Survey, 2004). However, not every purpose needs potable water; instead, water could be treated for reuse. Fortunately, much water produced in domestic settings is reusable.

Water is classified into categories based on its level of contamination. We will discuss greywater, black water and atmospheric water (Kinkade-Levario, 2007, pp. 2-3). Both greywater and black water, also called wastewater, collected from homes and offices are contaminated. Atmospheric water, also called rainwater, becomes contaminated due to atmospheric pollution and when it hits unclean surfaces like roofs or pavement before being collected. Fortunately, a variety of treatments for reusing water are available for all three contaminated water sources. Some treatments create potable water, which is water fit for human consumption.

2.3.1 Greywater

Washing machines, showers, tubs and hand sinks produce soapy water called greywater. Greywater can be filtered and reused in toilet flushing and garden irrigation (Al-Jayyousi, 2003). Use of greywater systems reduces the amount of water flowing into sewage systems and reduces the use of potable water when lesser quality will do. A. Dixion (2000, p. 305), a professor in Civil and Environmental Engineering at Imperial College of Science, Technology and Medicine in London, found that storing untreated greywater for longer than forty-eight hours causes quality changes; however, it may be beneficial to store it for at least twenty-four hours to reduce the amount of later treatment required.

Greywater filtration techniques largely depend on the amount and type of contamination in the water (Al-Jayyousi, 2003, pp. 183-187). The two main types of filtration are basic two-stage systems and biological systems. The first basic two-stage system is coarse filtration, which usually consists of a metal strainer and chemical disinfectants. Coarse filtration produces lower quality water than the other methods, thus lowering the potential for the water's reuse. The second basic two-stage system involves membranes to filter particles. While membranes usually provide better water quality, they have more upkeep such as cleaning and replacing the membranes. Biological systems combine the basic systems with biological treatment. Depending on the system design and water quantity, some biological systems need daily cleaning, while others can go as long as six months between cleanings. Biological systems make more sense for large-scale water users; they provide higher levels of water quality but at higher cost.

One of the centralized greywater reuse systems is not a reasonable choice for small buildings. A study conducted by E. Friedler (2008, p. 65) found that on-site greywater reuse only becomes feasible in buildings larger than seven stories containing 28 one-family flats. His research was based in Israel, which charges for both potable water and sewage. Additionally, some businesses use less water than households do, as they do not typically have washing machines, showers and tubs.

An alternative to a centralized greywater reuse system is a smaller scale, localized one. Water-Saver Technologies (2009a) has developed a system, AQUS, which involves a small collection tank installed under a bathroom sink that filters and treats the used water. The toilet tank receives water from the treatment tank. Figure 3 shows the AQUS system. Using the AQUS system will earn LEED points for both reusing greywater from bathroom sinks and reducing the amount of potable water used for toilet flushing (Heemer, 2006). Smaller buildings may find that using the AQUS system, or a similar product, makes much more sense for them.

Figure 3: AQUS greywater system. This figure demonstrates an installed AQUS greywater system (WaterSaver Technologies, 2009b, para. 2).

2.3.2 Wastewater

Wastewater contains a higher level of contamination than greywater due to bacteria from fecal and food matter. Contamination in toilet-flushed water requires much more treatment than greywater before reuse is possible. After treatment, wastewater can be used for irrigation, groundwater recharge and industrial uses (Chu, 2004, p. 2747).

There are two basic technologies for toilet water reuse: vacuum-biogas and urine diverting flush (Otterpohl and Buzie, 2011, p. 127). Since the 1990s, a variety of vacuum-biogas systems have been developed, however all are designed for large communities - some systems needing at least thirty house installations and others have a minimum of two thousand (pp. 129-103). Urine diversion combined with vermicomposting, a process that uses worms to decompose waste, is popular in Germany. Vermicomposting requires temperatures above 20°C, and installation indoors is possible (p. 131). These systems require a large community to support the system.

Another alternative is to reduce water used. A dry sanitation system does not use any water for toilets; thus there is no water for reuse (Otterpohl and Buzie, 2011, p. 133). The system consists of a pit used without the aid of water flushing; waste goes into a pit to naturally decompose. In order to utilize dry sanitation, the facility must have land for the pit. In addition, a second site is necessary for use after the first fills. Other drawbacks include odor and the potential for insect infestation. Dry sanitation is not feasible for an urban building with no open land. Another dry sanitation option is waterless urinals. They can replace a regular urinal, using the existing waste line and blocking the existing water supply line; thus they do not require new plumbing

(Waterless, 2011b). Gravity drains the liquid from the bowl and it sinks below chemicals that block the odor. The cleaning schedule for a waterless urinal is the same as a conventional one. Additional maintenance include replacing the chemical; the schedule varies depending on the number of users, with 3 ounces lasting 1,500 uses (Waterless, 2011a). Additionally, the trap needs to be replaced 2 to 4 times a year, depending on usage.

2.3.3 Rainwater Reuse

Rainwater is a source of fresh water that is often wasted by hitting the roofs of buildings and running off to the ground (Kinkade-Levario, 2007). Harvesting is the act of catching the water and diverting it for reuse. With a little bit of filtration, rainwater can be reused for irrigation and toilet flushing. Depending on materials used in collection, additional purification makes the water potable.

There are six components to rainwater harvesting: catchment, conveyance, filtration, storage, distribution, and purification (Kinkade-Levario, 2007, p. 14). Catchment is the surface on which the rain falls, from where it is transported by conveyance mechanisms to filtration. Roofs made out of metal, clay and concrete are best for potable water (p. 14). Commonly, gutters transport rainwater, but only some materials are safe for potable water: 40 PVC pipes and coated aluminum (p. 18). Filtration depends largely on the materials, contaminants and design of the system. Storage tanks must be large enough to collect the water harvested and must have the ability to drain when there is an overflow. If potable water is possible, purification is necessary with either additional filters and disinfectants or a solar distillation system. There are two distribution methods for filtered water, gravity or pumps, depending on the storage tank location and destination of water.

Rainwater yield depends on rainfall levels at the building's location and the size of the catchment system. In the U.S., common locations for rainwater catchment systems are located in areas with shortages of groundwater due to low rainfall (under 15 inches annually) such as Tuscon, Arizona, and Santa Fe, New Mexico (Kinkade-Levario, 2007, pp. 106-120). The low rainfall causes higher price for water from a public water source, increasing the motivation for a rainfall catchment system. San Juan, Puerto Rico, by comparison, has a much larger annual rainfall than Arizona and New Mexico, with an average annual rainfall of 59.43 inches (San Juan City, 1977). The larger rainfall means that a catchment system will be more effective than in Arizona and New Mexico. A single home in Friday Harbor, Washington, installed a rainwater catchment system due to saltwater contamination in the ground water supply (Kinkade-Levario, 2007, p. 106). With an annual rainfall of 42 inches and a catchment area of 5,000 square feet, the house collected approximately 117,810 gallons of potable water annually. To store the water, the family needed storage tanks to hold a total of 30,240 gallons.

2.3.4 Water Reducing Fixtures

In addition to reusing water, there are methods to reduce the amount of potable water used when it is unavoidable. The Energy Policy Act of 1992 required all toilets manufactured and sold in the U.S. to be low-flush; they must use less than 1.6 gallons per flush (U.S. General Services Administration, pp. 46-47). The General Services Administration (GSA) claims that replacing toilets made prior to the act would save "almost 5,500 gallons of water per person per year" (pp. 47-49). This policy sets a maximum for gallons per flush, but there are toilets that use even less water to save more.

WaterSense is a program created by the U.S. Environmental Protection Agency that provides information on making smarter water decisions (WaterSense, 2012c). Products such as faucets, toilets and urinals can earn the WaterSense label by being 20% more water efficient. By replacing toilets that use the standard of 1.6 gallons per flush with WaterSense labeled ones, you can save 4,000 gallons per year (WaterSense, 2012a). The standard for urinals is 1.0 gallons per flush; switching to a WaterSense labeled model with a maximum of 0.5 gallon per flush, you can save around 4,600 gallons of water per year (WaterSense, 2012b). Installing a urinal that uses no water can save even more water (Stumpf, 2007). Waterless urinals also use less energy to pump water and have reduced maintenance costs.

Sometimes the existing fixtures do not need replacement, rather just need repair. One drippy sink slowly wastes water, which adds up. A slow drip, one drip per minute, can waste 34 gallons per year; a fast drip, ten drips per minute, can waste 347 gallons per year; and a very fast drip, 30 drips per minute, can waste 1,041 gallons per year (U.S. Geological Survey, 2011).

2.4 Reconstruction Versus Renovation

The current average building lifetime in the United States is 75 years, assuming that the building will be demolished and rebuilt (Frey, Spataro, DiNola, Haas, Pike, 2011, p. 30). This takes into account all of the building materials, which means that materials like concrete and steel that have a much greater life span skew these numbers. Many materials in a building have life spans that are far less than 75 years. Once a building reaches its maximum life, it is necessary to perform repair or reconstruction. The two options for the rehabilitation of the building are new construction and renovation.

2.4.1 New Construction

A billion square feet of buildings are demolished and replaced with new construction every year (Frey et al, 2011, IX). Human beings have recently become aware of their impact on climate change, but there have been few studies of the impact of new construction. Construction, operation and demolition of buildings are the cause of over 40 percent of the United States' carbon dioxide emissions (Building Sustainable Communities, 2011). There is a value of having new, green construction, but new construction uses energy, natural resources, and creates a large amount of waste, which can have negative effects on the environment. If only one percent of Portland, Oregon's office buildings and single-family homes were retrofitted instead of being demolished and reconstructed, then in the next ten years, fifteen percent of that county's CO_2 reductions would be met (Frey et al, 2011).

2.4.2 Renovation

In comparison to reconstruction, reuse and renovation of a building can greatly reduce the effects on the environment. It can take 10 to 80 years for new energy efficient systems to overcome the environmental effect of construction, assuming that the new building is 30 percent more efficient than an average existing building (Frey et al, 2011, p. 84). In comparison to new construction, reuse has environmental savings between 4 and 46 percent (Frey et al, 2011, p. VI). Furthermore, the reuse of a building offers immediate reductions to climate-change, whereas new construction would emit large amounts of negative climate change factors in the construction process. Regardless of climate and building type, the reuse of a building is almost always the best way to have an impact on climate change and the environment, while making the building reach its maximum efficiency.

Preserving a structure can have a positive effect on the economy. Each preserved historic building provides a story of the era of its origin and can be a link to the past (Frey et al, 2011, p. 15). The National Trust for Historic Preservation states that historic rehabilitation has a thirty-two year track record of creating two million jobs and generating ninety billion dollars in private investment. In addition to the preservation of cultural and historical values, the environmental impact factors are another reason for using renovation instead of new construction.

Historic buildings often put forth the obstacle of outdated utility systems, such as electrical wiring, lighting, air-conditioning, heating, plumbing, etc. (Terry, 2008). In most cases, these systems will often consume more energy and run inefficiently. Owners frequently plan a renovation project centered around energy systems, because they hope to recover some of their costs through the long-term energy savings (S. Magill, personal communication, February 11, 2012). Government regulations sometimes necessitate updating the mechanical and electrical systems of older buildings if they are deemed unsafe for occupancy. Bathroom fixtures and piping also grow old with a building, and as they reach a certain age, they will no longer run efficiently and may actually be wasting water. Plumbing in a building can be updated with new piping and low-flow fixtures, which can go a long way in conserving water.

Installing new systems is not a simple task in most cases; in his report, Terry (2008) explains some of the construction problems that were faced in his three case studies. Many renovations require builders to install equipment in limited space, which can be an issue, for example, with the large ductwork that HVAC systems need. The structure of a building will sometimes have to be reinforced in order to carry some of the loads that come with new systems. It is often difficult to retrofit efficient lighting into a historic building because owners want to retain the aesthetics of the old lighting. Sometimes, owners will allow bathrooms to be completely renovated, with little concern to preserve features. This usually works in favor of the owner because an efficient system will conserve water, which saves money, and it can often still be aesthetically pleasing with modern, elegant designs that complement the historic nature in the rest of the building. In all cases, though, the major challenge is performing the construction without changing any defining historic features of the building.

2.5 Current State of Energy and Water Conservation in Puerto Rico

In 1992, Puerto Rico remembered the 500th anniversary of Columbus arriving in the Americas in 1492 (Galván, 2009, p.140). As part of this event, Puerto Ricans introduced a plan to renovate various historic buildings throughout the island. Galván (2009) states that "over four hundred buildings in Old San Juan are being restored to update the tile roofs, ornate balconies, and colonial features of tropical architecture" (p. 140). The restoration projects focused on retaining as much of the buildings' historic character as possible. Builders are attempting to use the original materials; some elements can be reused, but if not, parts from abandoned buildings or imported parts from Europe can be used. While some of these renovations will improve energy and water efficiency, the main focus of these projects was to increase the interest of tourists.

Currently, Puerto Rico has an agency dealing with energy and water conservation, the Puerto Rico Energy Affairs Administration (AAE) (North, Heath, Evansen & Champagne, 2010). In October 2009, the AAE received $9,593,500 from the American Reinvestment and Recovery Act (ARRA) to fund alternative energy and energy conservation projects. Using this fund, the AAE, in conjunction with the Puerto Rican Infrastructure Financing Authority (AFI), developed a rebate program for energy efficiency updates for non-profit, government, and commercial organizations. To receive the rebate, the entity must complete the update within six months of being accepted and undergo a professional audit. In addition to that, the program also provides rebates for individual families who use ENERGY STAR products.

2.6 Fideicomiso's Buildings

The Conservation Trust of Puerto Rico currently owns two historic buildings, Banco Español and Casa Ramón Power, in the Old San Juan district. They date back to the 18th and 19th centuries and are currently outdated and in need of renovation. The Trust intends to use the two buildings as the headquarters of the organization in the future.

Casa Ramón Power was renovated by the Trust in 1996 and currently holds offices, conference rooms and an exhibit space for educating the public about nature and environmental conservation. It is historical because it was the birthplace of Ramón Power, the first representative of Puerto Rico to the Spanish courts. Banco Español was acquired by the Trust in 2006, little is known to the Trust about the building before the acquisition. Banco Español was used as offices for the Trust until July 2011, when they moved due to structural concerns about the building. The offices were moved to a temporary location at 201 Tetuán Street. The future plan is to renovate Banco Español and move all the offices from the current locations of Casa Ramón Power and 201 Tetuán Street back to it. After that Casa Ramón Power will only be used for educational purposes, with an expanded exhibit area.

2.7 Summary

The Trust wants to be a role model of energy and water efficiency to better protect the environment via their buildings' renovation projects. In this chapter we have explained many methods for energy and water conservation. Previous research has shown that electricity savings in existing buildings can come from using more efficient devices such as light bulbs and air conditioning units, using alternative energy sources such as wind or solar power, and using building renovation instead of new construction. People can reduce fresh water usage by reusing greywater, wastewater and rainwater. No prior research has ever focused on improving water and energy efficiency or determining a proper energy assessment standard of the Trust's two historic buildings, Casa Ramón Power and Banco Español. In addition, research has not focused on the cost-efficiency of the renovations to improve their water and energy efficiency.

3 Methodology

The goal of this project was to recommend cost efficient modifications that can be made to the Conservation Trust's two buildings in Old San Juan to make them more energy and water efficient while preserving their historic character. We also identified potential education topics for the buildings' occupants with respect to their energy and water conservation habits and ways of educating the public about the energy and water savings in buildings. To achieve our goals, we developed the following methodology, which included observations, archival research, interviews, and a cost-benefit comparison. The following sections explain how we achieved each objective and detail each method's purpose and justification.

3.1 Current Energy and Water Use of the Trust's Buildings

We determined the current water and energy usage of the Trust's two buildings in order to create a baseline of energy and water usage. Our goal was to learn as much about the buildings as we could in the short period of time allotted for the project. The information, observations, and data collected from this process informed our further investigations and allowed us to make recommendations on methods of energy and water savings. The main ways of determining the current energy and water usage were using observations, archival research, and interviews.

3.1.1 Observations of the Trust's Buildings

In order to make accurate and cost-efficient recommendations, we observed the buildings as they currently existed. Through our initial walkthroughs, we learned that Banco Español was not in use; the building was currently empty of any offices and in need of a large amount of repair. Casa Ramón Power contains administrative offices, so an analysis of existing energy and water use was much more important for this building than Banco Español.

We first investigated the current use of Casa Ramón Power. We inventoried the number of computers, lights, toilets, faucets, air conditioners and other office equipment. We recorded these details in the data recording form found in Appendix B, which allows us to view devices by floor. This process allowed us to determine a baseline of all the devices used in the building and helped us recommend potential replacement to more efficient devices.

After arriving in San Juan, we found that we had to analyze another office building in addition to the two historic buildings. The Trust has been using 201 Tetuán Street as a temporary office space. The plan is to move all of these offices over to Banco Español. As with Casa Ramón Power, we analyzed 201 Tetuán Street with respect to energy and water-using devices that the Trust will move to Banco Español. We recorded the device data in the same form, found in Appendix B.

3.1.2 Archival Research

We improved our understanding of the baseline by determining the energy and water usage by month. We found out how many kilowatt hours of electricity the Trust pays for and uses every month in Casa Ramón Power by reviewing energy bills from Dec 2009 to Nov 2011. In Banco Español, we looked at electricity bills from Dec 2009 to July 2011 to better understand the energy usage of that building. These bills helped with the analysis of the efficiency of the electrical systems, and to identify potential problems of energy use in the buildings. Similarly, we determined a baseline for water usage in each building, and how much the Trust paid for it in order to identify savings from different water systems.

3.1.3 Interviews

We conducted interviews with ten of the Trust's employees located in Casa Ramón Power and 201 Tetuán Street to evaluate their energy- and water-efficiency knowledge and habits. See Appendix D for the interview protocol. The detailed results of these interviews were kept anonymous and confidential. The information gained from the interviews allowed us to understand the energy and water needs and desires of the occupants. We also learned of their habits and knowledge gaps about water and energy conservation. We conducted additional impromptu interviews with twenty-eight staff regarding printer usage in both Casa Ramón Power and the office on 201 Tetuán Street.

3.2 Current Energy and Water Use in Old San Juan

Comparisons of the Trust's buildings with other buildings in Old San Juan that have been renovated to be more "green" provided us with valuable information on the techniques that have been used in other buildings in the area to improve energy and water efficiency. Buildings in Old San Juan were important to look at because many of the buildings are also extremely old and experience the same environmental conditions such as sun, wind, and rain. We identified what methods have proven to be effective for energy and water conservation in buildings similar to the Trust's buildings. These results provided information on the amount of savings that specific types of renovations have achieved in other projects around the area.

We interviewed an engineer, an architect and a construction project manager to understand the construction process in Puerto Rico and the results of similar renovation projects in Old San Juan. These professionals provided us with advice on methods to consider. Our main goal of the interviews was to meet with people who have experience with historic building renovations in Old San Juan. See the interview protocol for construction professionals in Appendix C. We asked questions about special constraints in Old San Juan, any buildings that are energy and water efficient in the area, and opinions on cost effective green products. As in previous interviews, we provided each interviewee with confidentiality and kept responses anonymous, when requested. Determining what others have done provided valuable guidance that helped us to provide appropriate suggestions for renovation methods to be used on the Trust's buildings.

First, we interviewed Alex Nazario, a construction manager for Aireko Enterprises, one of the largest construction companies on the island. Next, we interviewed Mark McCullough, a contact that Matt Burger provided, who is an employee of Consigli Construction we had already interviewed (see Appendix G). Last, we interviewed Carlos Rodriguez, an engineer that our liaison, Juan Rodriguez, connected us with.

In addition to the interviews, we examined the U.S. District Courthouse in Old San Juan, which Alex Nazario mentioned had been renovated to be more energy efficient. Through observation, we took notes of any specific things we saw that could help us in our recommendations to the Trust. Before suggesting any energy conservation methods, the existing energy-efficient characteristics of both Cuartel de Ballajá and the U.S. District Courthouse were assessed. A building's performance varies due to its design, materials, type of construction, size, shape, site orientation, surrounding landscape and climate. Identifying and understanding any original and existing energy-efficient aspects of a building is key to having a successful rehabilitation. It was important to utilize the building's sustainable qualities and to be aware that sometimes the existing building is the most sustainable. As with energy, building design and location affected its ability to achieve water conservation. Other buildings in Old San Juan have come up with solutions to similar design and location restrictions. We determined the methods that would benefit the Trust in overall water and energy efficiency and potentially be also allowable by zoning laws given to us by Juan Rodriguez.

3.3 Compare the Costs and Savings of Proposed Methods

After identifying the potential renovation methods that could be applied to the Trust's buildings, we estimated the cost and annual monetary saving of each method. Comparing the costs to the benefits of the renovation and predicting the number of years that the investment on each method would be paid off allowed us to determine the feasibility of the methods for each building. To keep our calculation simple, we did not consider inflation rate or interest rate. We also calculated the percentage of energy and water conserved based on previous utility data to better support our decision.

3.4 Education on Water and Energy Conservation

The first part of the education plan focused on recommending changes of habits of the occupants of the Trust's buildings. Based on the information collected in the interviews with the buildings' occupants, we were able to identify their habits that lead to some inefficiency in water and energy use. We were also able to suggest the methods and strategy of conserving energy and water that they were not aware of. The purpose of the educational plan was to make the occupants of the buildings more aware of how to save water and energy in their daily lives.

Furthermore, the Trust's administrators made it clear that they hoped to become a role model for energy and water conservation in buildings. In order to do this, it is imperative that the Trust advertises and educates the public about the steps they are taking and have taken to improve their buildings. We investigated methods to educate the local population on the actions that the Trust will be taking. To determine education methods, we looked into the methods that have been used by similar building owners to promote the actions of energy and water conservation. We interviewed Juan Rodriguez who is in the group of education and communication and asked him about the effective steps that the Trust takes to educate the community about the "green" efforts they participate in. Questions in the interview also included what the interviewee felt would best promote the Trust as a role model. See Appendix E for the interview protocol. Based on the information collected, we were able to recommend ways to promote education on the subject.

3.5 Summary

We needed to consider many factors before determining the appropriate technologies to apply to improve energy and water efficiency in the Trust's buildings. Our methods allowed us to have a baseline from which to judge possible improvements, and insights into what has worked and what has not worked in the immediate area. With the methods completed, we were able to analyze the data collected in the next chapter.

4 Results and Analysis

This chapter of the report provides the results of our research into how to make the Trust's two historic buildings more energy and water use efficient. We present our findings and discuss their significance. Along with the utility bills for the buildings, we have analyzed the technologies currently used in the two buildings to understand the existing situation. We also present insights gained from all of the interviews we carried out. We discuss how we achieved each of our research objectives, starting with codes and regulations that relate to this project, followed by current energy and water use in the buildings, then suggestions for how to improve these buildings with the assistance of outside professionals; we finish by identifying educational opportunities both for the Trust's staff and for the public about how to manage their energy and water use more efficiently.

4.1 Codes, Regulations and Rating Systems

This section covers the research and analysis of various building codes and rating systems and how they are or are not applicable to the Trust, and the regulations that the Trust must follow during the renovation process.

Although the International Energy Conservation Code (IECC) is used to regulate the design and construction of buildings for the effective use of energy (ICC, 2009), its first chapter indicates that historic buildings are exempt from this code. Thus we are not going to refer to this code for our project.

Although LEED is a commonly recognized rating system, the Trust's two buildings are difficult to encapsulate within its parameters. If the Trust is going to seek LEED certification, they need to put significant effort into the planning, analysis, and design phases of the project and should have sufficient budget. Among all five credit categories of LEED, the Trust's renovation project might score easily in Materials and Resources, and Indoor Environmental Quality, but struggle for points in Sustainable Sites, Energy & Atmosphere, and Water Efficiency (non-landscape), as suggested by the previous data (U.S. Department of Energy, 2005). Transforming the way the building is designed, built and operated to earn LEED certification might conflict with historic preservation. As a result, LEED is not an appropriate standard for this project to refer to.

Unlike other energy codes and rating system, the EPA's ENERGY STAR program stresses the importance of energy and water management. In addition to listing energy-efficient products with the ENERGY STAR label, EPA's ENERGY STAR program offers a rating system as well as useful online tools to help manage the energy and water consumption in an existing building or building portfolio. This source will be useful for the Trust to refer to before and after the renovation. We learned that through quick registration on the ENERGY STAR website and inputting the data (building space, energy and water consumption, etc.), the building manager or owner can use the Portfolio Manager to track and assess energy and water consumption, identify opportunities for energy efficiency improvements, track the improvements' progress over time and verify the results (ENERGY STAR, 2012). Along with the online tools, the EPA offers many other resources and a strategy for superior energy management. The strategy they suggest consists of a series of steps to manage and improve energy and water use efficiency, beginning with making a commitment, followed by assessing performance, setting goals, creating an action plan, implementing an action plan, evaluating progress, and recognizing achievements both internally and externally. The process is illustrated in Figure 4 below.

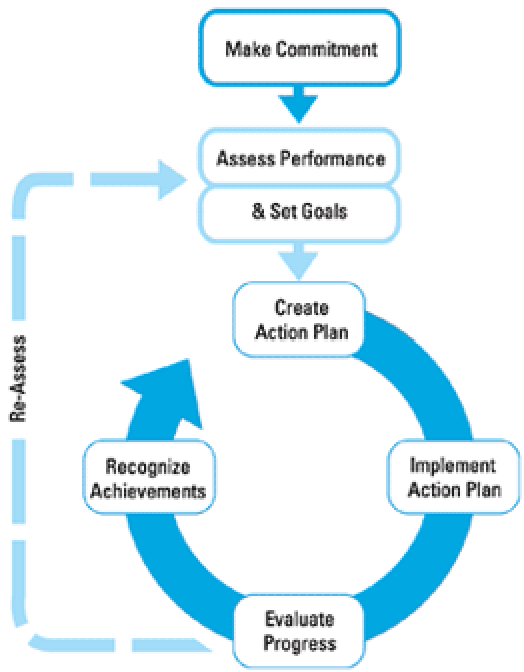

Figure 4: Energy and Water Management Strategy. This figure illustrates the continuous process in managing the energy and water consumption (ENERGY STAR, 2012, para. 1).

After improving their management in water and energy use, the Trust can acquire external recognition by joining the ENERGY STAR partnership program. The program would provide the Trust with ENERGY STAR building labels for the buildings that meet various standards of performance, such as those established by ENERGY STAR, that reflect superior building energy and water performance.

Despite of all the codes, rating systems and recommendations from various organizations, there are many constraints set up by the zoning regulations with respect to historic buildings. For example, in the Regulations for the Designation, Registry and Preserving Historical Sites and Areas in Puerto Rico, also known as Planning Regulation No. 5, the Planning Board of Puerto Rico (2002) stated that all properties must be used for their historic use and the renovation, if required, must not affect the characteristics that define the buildings. The building height, roof and windows have to be similar to other buildings on the street or in the sector. No new construction, installation or signs are allowed on the facade, gallery or balconies. However, these regulations were stated in a very general way so that no specific renovation methods are banned. Therefore the Trust may need to seek further advice from construction professionals or Planning Board officials.

4.2 Baseline of Energy and Water Consumption

In this section we present the current energy and water use patterns in the Trust's two buildings and analyze why they are that way.

4.2.1 Energy Consumption

Although the Trust has already taken some steps to conserve energy, the electricity consumption in both buildings has still been high and thus needs to be improved.

In Casa Ramón Power, the office building currently in use, we found that the lighting and many devices are updated and efficient. All light bulbs in the overhead lights are fluorescent light bulbs. They do use ENERGY STAR products, including printers, AC units, and so forth. The air conditioning system, renovated in 1996, consists of up-to-standard equipment. The rooftop chiller is AHRI-rated, the equivalent of ENERGY STAR for HVAC systems. Moreover, the results from the interviews with building occupants suggested that most people do have a sense of the need for energy conservation. For example, all interviewees from Casa Ramón Power turn off the desk lights, if any, before leaving and keep windows closed while the individual AC is on. They also turn off their computers or monitors when leaving the office.

Even with many updated devices and pieces of equipment, Casa Ramón Power still consumed a daily average of 513.7 kWh during Dec 2009 to Nov 2011, contributing to an average monthly charge of $4366.57. The efficiency of the use of the power is relatively low, with an average power factor of 0.85, which means that only around 85% of the power turned in to the actual use of electricity. This low power factor also contributed to high charges for electricity. Detailed information regarding energy bills can be found in Appendix L.

The inefficiency of energy consumption exists due not only to the design of the system but also the improper use of devices by occupants. From the interviews with building occupants we learned that the lighting system in Casa Ramón Power is centrally controlled, except the exhibition room, which means that an individual occupant is not able to shut down the overhead lights in his/her section of the office while away from the building. The AC units in Casa Ramón Power are individually controlled, allowing users to choose the temperature they want. However, 4 out of 6 interviewees said that they sometimes felt cold in the office. Additionally, the AC must be on higher due to the single-pane glass in the windows, which usually does not have very good performance in blocking the heat gain from daylight.

Redundant devices are also unnecessary energy consumers in the office. For example, in Casa Ramón Power, there are 9 printers in total for 15 occupants while only 2 are most commonly used. On the first floor of Casa Ramón Power, there are 6 printers. We asked 9 occupants on that floor which printers they use and found out that only one is most commonly used with 8 users. The rest of the printers are used by only 0-2 people. Among the 3 printers on the second floor, one has 3 users, one has 1 user and no one uses the other one. Below are two figures, Figure 5 and Figure 6, of the printer usage distribution of Casa Ramón Power. The Letter P stands for printer and the number beside the letter P stands for the number of users of that printer.

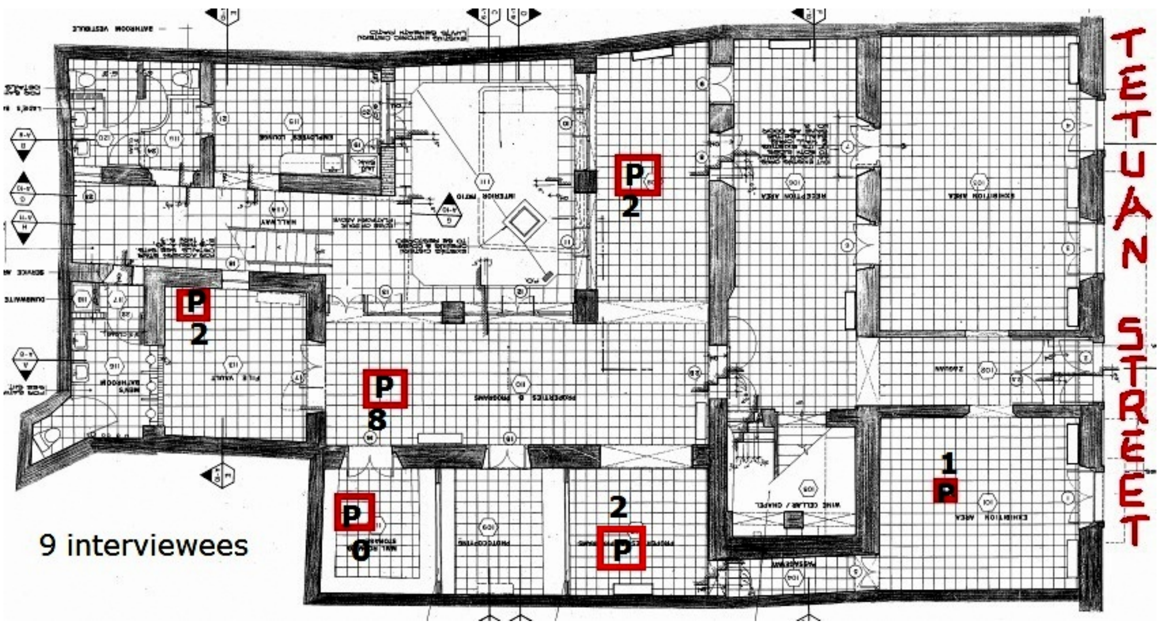

Figure 5: Printer usage distribution in the first floor of Casa Ramón Power. This figure illustrates the location of the printers on the first floor of Casa Ramón Power and the number of users of each printer.

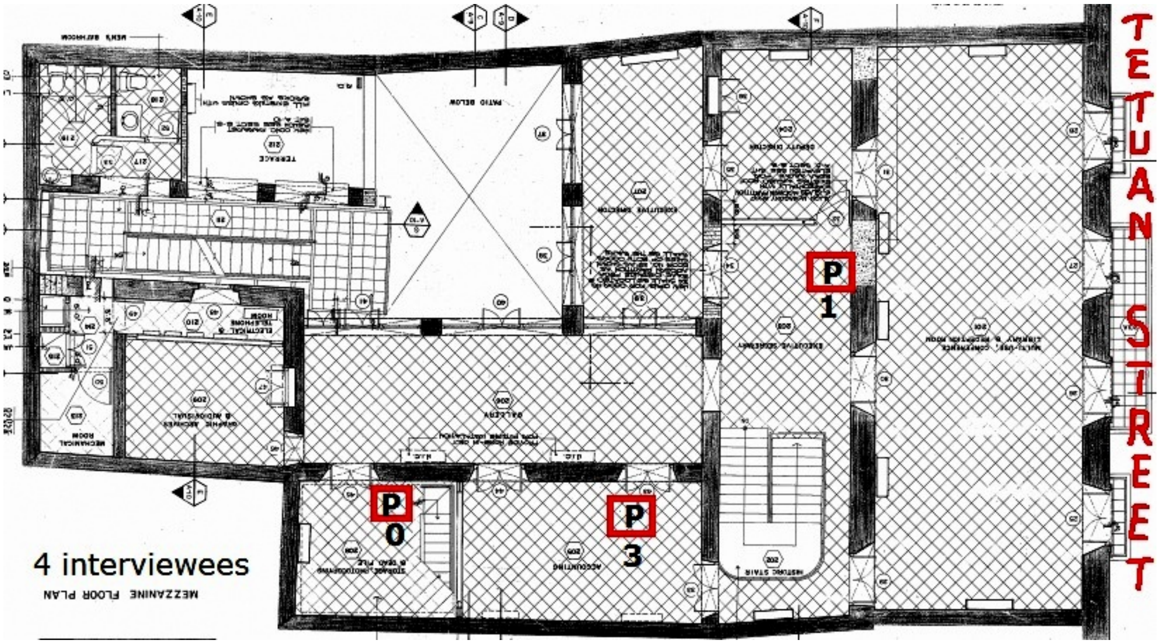

Figure 6: Printer usage distribution in the second floor of Casa Ramón Power. This figure illustrates the location of the printers on the second floor of Casa Ramón Power and the number of users of each printer.

We found a similar problem in the Trust's temporary office at 201 Tetuán Street where the printers to occupants ratio is 14 to 25. In addition, based on our interviews with building occupants we learned that some people lack knowledge about how to conserve energy.

The Trust's other building, Banco Español, is currently not in use. In the past, only the ground floor was used as offices for 14 occupants and did not have exhibition rooms for visitors. The ground floor had sufficient sunlight and therefore little lighting was needed. The centrally controlled AC system was outdated. Electricity consumed there was relatively lower with an average daily consumption of 149.05 kWh from Dec 2009 to July 2011.

Comparing the energy consumption of the two buildings to the average monthly temperature in San Juan, we discovered that the correlation between the temperature and energy consumption in Banco Español is 0.60, greater than 0.33, which is the correlation coefficient between the temperature and energy consumption in Casa Ramón Power. This means that the energy consumption in Banco Español was more influenced by the changes in outdoor temperatures, possibly due to the fact that this building is more outdated.

4.2.2 Water Consumption

From the water bills, we determined that the Trust uses about 5,997 gallons monthly in Casa Ramón Power, which is approximately 375 gallons per person. When Banco Español was in operation, they used about 2,061 gallons monthly, which is approximately 147 gallons per person. Detailed information regarding the water bills can be found in Appendix L. We looked into the large difference in consumption per person between the buildings, and discovered one water bill was a lot higher than the rest. Removing this bill significantly altered our findings, as seen in Table 1. Our liaison, Juan Rodrigez, did not know why the bill was so high, so it is likely it was a one time maintenance issue. However, we decided to use the actual numbers for our analysis.

Table 1: Water Consumption in Casa Ramón Power (CRP) and Banco Español (BE) (in Gallons)

	CRP (Original)	**CRP (Adjusted)**	**BE**
Monthly Average	5,997	4,486	2,061
Yearly Average	71,960	53,827	24,726
Num. of People	16	16	14
Monthly Average per Person	375	280	147
Yearly Average per Person	4,497	3,364	1,766

Being an office building, the Trust's Casa Ramón Power building doesn't have many water fixtures. The occupants use sinks, toilets and urinals. During our initial tour of Casa Ramón Power, we discovered it has one shower. Our liaison informed us that the shower is only used to fill buckets for cleaning, and thus can be considered a sink. On our subsequent tours of the building, we discovered that Casa Ramón Power has six toilets, all of which meet the Energy Policy Act standard of 1.6 gallons per flush. The three urinals also meet the standard of 1.0 gallon per flush. We noticed that at least one sink of the six in Casa Ramón Power was dripping, meaning that water was being wasted there all the time.

4.3 Energy Conservation

Due to the relatively high energy consumption in the Trust's buildings, we examined ways to reduce their energy usage. Through interviews and observations of other buildings in Old San Juan, we were able to learn more about the potential devices and methods in the area that have worked to conserve energy. When asked about making any type of renovation to a building in the historic district, Alex Nazario of Aireko Enterprises stressed that there will most likely be resistance since some historians and citizens do not want the buildings updated; they fear that the building will lose its historic character. He emphasized that once an organization can get the community to back a project, it tends to run much more smoothly. He explained that the major energy-consumer in a building, especially in Puerto Rico, is the HVAC system of a building. He said that in most projects, an engineer or designer would simply recommend an additional layer of insulation on either the inner or outer walls; in the case of a historic building, however, this is not possible.

Nazario discussed the massive Aireko renovation of the historic Cuartel de Ballajá building in Old San Juan. In the project, Aireko completely restored the building's weathered exterior and did not change the looks too drastically because Old San Juan is very strict about changing any historic buildings. Aireko installed new cooling towers, chillers, a building monitoring system (BMS), and automatic controls as part of the HVAC retrofit. The BMS and automatic controls can sense when a zone or room of the building needs more or less air, needs an increase or decrease in temperature, and whether or not a room is occupied. This system is also integrated with the lighting controls to turn the lights off in unoccupied rooms, which is one more step to improving energy efficiency. Nazario added that the entire building was analyzed to find areas where air could be leaking or where air conditioning might not run efficiently. After this examination, specialists were brought in to fix any leaks and help improve the overall efficiency of the HVAC system. In an attempt to save even more energy, the project also included the installation of a photovoltaic (PV) system. The 151.2kW system includes 720 photovoltaic panels attached to the rooftop. The system saves the building $42,000 in energy costs per year. With the combined HVAC overhaul and added PV system, Aireko predicts the client to have a return on investment within seven years. The two systems help to reduce the Cuartel de Ballajá's carbon dioxide emissions by 683 tons per year, and save 77,403 gallons of combustible fuel per year. President Barack Obama even took note of the work being done by Aireko when he mentioned the Cuartel de Ballajá project during a visit to Puerto Rico:

> Maybe some of you remember that when I was here in 2008, I spoke in front of the Cuartel de Ballajá, a site that had been home to so many chapters of Puerto Rican history. Today, Puerto Rican workers are writing the next chapter by turning the building into a model of energy efficiency. They're making HVAC systems more efficient. They're putting on a green roof. They're installing 720 photovoltaic panels. When they're done, it's estimated that the energy savings will be 57 percent. And Puerto Rico will have taken one more step towards creating a clean energy economy. (Cuartel de Ballajá powerpoint presentation, Aireko, Appendix H)

The government plays a big part in making Puerto Rico more energy efficient. The government began offering incentives in Puerto Rico for qualified projects in 2010 through a program called the Puerto Rico Green Energy Fund (Puerto Rico Does It Better, 2011). The program is split into two tiers: projects rated less than 100kW can receive up to a 60% credit, and projects rated more than 100kW can receive up to a 50% credit. Without these incentives, many people would be hesitant and reluctant to install expensive PV systems or wind turbines. Incentive programs will usually involve an application process that can vary from first-come, first served to competitive applications that are evaluated in depth. The government usually bases the incentives on the size of the system, where the system will be (i.e. residential, commercial, etc.), the type of system (solar, wind, rain reuse, etc.), and several other factors. Nazario made a point that on such a small, isolated land mass, the government should keep pushing these alternative energies because that the available resources are limited.

Using online calculators and several other resources, we were able to estimate the feasibility of photovoltaic (PV) systems on the roofs of the Trust's two buildings. The three main websites that we used to estimate data regarding PV systems for the Trust's buildings were SRoeCo Solar (2012), SolarEstimate.org (Energy Matters, 2012), and PV Watts (National Renewable Energy Laboratory, 2012). Table 2 shows the information that we entered into the different calculators to estimate these costs.

Table 2: Information for PV System Calculators

Cost per kWh	$0.27	
Average sunlight per day	7.8 hours*	
	Casa Ramón Power	**Banco Español**
Roof area (sq. ft.)**	1,700	4,000
kWh per year***	180,700	52,000

*(Climatetemp.info, 2011)
**Estimated usable space for PV system
***Based on current electric bills

Through calculations, we were able to estimate the costs and benefits of PV systems for each building. Each analysis produced dramatically different results.

A PV system for Casa Ramón Power would be optimal with a rating of about 23 kW; this is the total power rating of the array of panels. The system rating could be satisfied by any combination of solar panels, ranging from 92 panels with a 250 Watt rating to 115 panels with a 200 Watt rating. For this study, we assumed the use of 88 panels rated at 260 Watts each. The average panel size is 17 to 20 square feet, so the PV system for Casa Ramón Power would take up 1,500 to 1,700 square feet (SRoeCo Solar, 2012). For this analysis, we assumed the use of Yingli Solar Panda YL260C-30b, 260W Solar Panel, which cost $325 each (Affordable Solar, 2012). We chose this specific panel because it has a price of about $1.25 per Watt, which is on the lower end for solar panels. We also assumed that equipment for the system costs between $3 and $4 per Watt, and installation costs between $0.60 and $1.00 per Watt (Wayne Griffin, personal communication, April 18, 2012). Solar panels require little to no maintenance over their 20 to 30 year lifespan, so maintenance costs were not considered. So for Casa Ramón Power's PV system, the cost would consist of $28,600 for the solar panels, about $80,500 for equipment, and about $23,000 for labor to install the panels. In total, the system is estimated to cost $132,100.

This total cost may seem expensive, but with the help of government incentives, the price decreases greatly. As mentioned, the Puerto Rico Green Energy Fund offers a rebate of 60% of the total eligible project cost to any projects that qualify and have systems rated less than 100kW. There are also federal incentives that could be used towards the PV system, including the Renewable Energy Grant provided by the U.S. Department of Treasury, which provides up to 30% of the project costs related to the PV system (DSIRE, 2011). Both these incentive programs require an application process in which the organizations review the projects to ensure that money given out is equally spread between residential and commercial, profit and non-profit, small and big projects, etc. We believe these two incentives are the two best suited to the Trust, but acceptance to the Renewable Energy Grant could be more difficult because it is offered in all 50 states and any U.S. territories. The Puerto Rico Green Energy Fund would decrease the cost to $52,800. If both these incentive are won, the cost for the PV system for Casa Ramón Power could be cut to $13,210.

With the high energy consumption depicted in the energy bills of Casa Ramón Power, this PV system would only be able to cover 18% of the Trust's annual energy consumption, producing 32,208 kWh of energy, or about $8,700 of energy, per year. The system would gain value as the price for energy from fossil fuels increases and the resources deplete.

Banco Español has more flexibility when considering a PV system; with more available roof space and potentially less energy consumption, solar panels could be very beneficial for the building. The PV system for Banco Español should have a rating of about 37 kW. Again, this rating can be satisfied by various arrays of solar panels, but for this study, we considered a system of 152 panels rated at 245 Watts. Assuming the same average panel sizes, this system would require between 2,584 and 3,040 square feet. For this system, we assumed the use of Schott Poly 245, 245W Solar Panels, which cost $330 each (Affordable Solar, 2012). We chose this specific panel because it has a price of about $1.35 per Watt. Again, we assumed that equipment for the system costs between $3 and $4 per Watt, and installation costs between $0.60 and $1.00 per Watt (Wayne Griffin, personal communication, April 18, 2012). So for Banco Español's PV system, the cost would consist of $50,160 for the solar panels, about $129,500 for equipment, and about $37,000 for labor to install the panels. In total, the system is estimated to cost $216,660. The same incentives apply for this building, so after the Puerto Rico Green Energy Fund credit, the system could cost $86,664; with both incentives available the costs could be cut to as little as $21,666. This system has the potential to cover almost 100% of the total energy consumption in Banco Español, assuming the building's energy use does not change from the year-long period of electric bills we analyzed. The system could produce 50,412 kWh of energy annually, or about $13,600 worth of energy. We assume that the percentage of energy covered will decrease because our example used bills when only one floor of the building was occupied.

Since the PV system for Banco Español has the potential to produce almost all the necessary energy for the building, there is a chance that the panels collect excess sunlight that is not needed (Gangemi, 2006). If the system is tied into the grid, the Puerto Rico power companies might allow the Trust to sell back the energy. Most states in the U.S. offer incentives to systems that produce extra energy that is not needed. So along with incentives for the installation of a PV system or wind turbine, there is additional return if the system is able to produce more than enough energy and a utility company is willing to purchase it.

The solar panels for both example systems have a return on investment of two to seven years. A return on investment (ROI) is a term used to evaluate the efficiency of an investment. For the analysis of an alternative energy source we referred to the ROI as time needed to balance the gains and investment. The two to seven years is an estimate based off of the amount of government incentive that the solar panels could be approved for. For the Puerto Rico Green Energy Fund with a 60 % incentive, the ROI would be seven years. If the panels were also approved for the Renewable Energy Grant by the U.S. Department of Treasury, for an extra 30 % incentive, the ROI would be reduced to two years. It can be seen that the government incentives for solar panels have a large effect on the ROI. Without government incentives the installation of solar panels would not be an economically attractive option.

Along with PV system planning, there are several online tools that helped us determine some of the details about a wind turbine for the Trust's buildings. EnergyEfficientChoices.com (Alternative Power Choices, 2009) provided a wind turbine sizing calculator, while SolarEstimate.org also provides a wind estimator tool. Both websites determined San Juan as an excellent place to use wind power, with an average wind speed of about 15mph (at a height of 164 feet). For these buildings, we analyzed the feasibility of a 10 kW wind turbine, one of the larger models of the small windmill category. A turbine of this size would cost $31,770, plus about $15,000 for miscellaneous equipment (Bergey Wind Power, 2011). This price tag of almost $47,000 can be discounted by the same incentives that are offered for solar panels. The Puerto Rico Green Energy Fund incentive could cut the price to $18,700, and if accepted by both programs, the wind turbine could have a potential cost of $4,677. There are additional maintenance costs that average 1.5 - 2 % of the original investment per year, with the average lifespan of a turbine being 20 years.

Based on the average wind speeds in the area, it is predicted that a 10 kW wind turbine could produce about 20,000 kWh, or $5,400, of energy per year. This is almost 40% of Banco Español's previous annual energy consumption, and about 11% of Casa Ramón Power's current annual consumption. If necessary, a second 10 kW wind turbine could be explored, which would double the cost, but also double the amount of energy produced annually.

The return on investment (ROI) for wind power is the time needed to balance the cost of the wind turbine and the value of the energy produced by the turbine. For our example with the 10 kW wind turbine, the ROI was one to four years. If the Puerto Rico Green Energy Fund incentive of a 60 % discount were approved for the turbine, the ROI would be four years. If the panels were also approved for the Renewable Energy Grant for an extra 30 % incentive, the ROI would be reduced to one year. It can be seen that the government incentives for wind power have a large effect on the

ROI. Like solar panels, without government incentives the installation of wind turbines would not be a feasible option. However, if the wind turbines were approved for the same incentive as solar panels, the turbines would provide a quicker ROI.

The information regarding the PV systems and wind turbines can be found in Table 3.

Table 3: Proposed PV Systems and Wind Turbines

	Solar Power		Wind Power	
	CRP	**BE**	**CRP**	**BE**
System Size	23 kW	37 kW	10 kW	10 kW
Individual Unit Size	260 kW	245 kW	10 kW	10 kW
Number of Units	88	152	1	1
Annual Energy Output	32,208 kWh	50,412 kWh	20,000 kWh	20,000 kWh
% of Annual Energy Covered	18%	97%	11%	40%
System Cost	$132,100	$216,660	$46,770	$46,770
Cost after PRGEF	$52,800	$86,664	$18,700	$18,700
Cost after PRGEF Renew. Eng. Grant	$13,210	$21,666	$4,677	$4,677
Return of investment*	2 - 7 years	2 - 7 years	1 - 4 years	2 - 4 years

*Depends on which incentives are applied

In an interview with architect Mark McCullough from McCullough Domínguez Architects, we were able to examine additional methods of water and energy conservation. McCullough mentioned that it is crucial to utilize the natural sources of energy. He emphasized the importance of utilizing natural lighting, but at the same time keeping the direct sunlight out of the building will keep it much cooler. In addition, he discussed the option of passive cooling, which is very popular in Old San Juan buildings because they date back to the 18th century and are mostly masonry or concrete structures. The passive cooling in Old San Juan uses the patio space and wind to create a ventilation system throughout the building.

Other than Cuartel de Ballajá, it was difficult to find any other buildings in Old San Juan that were renovated to be energy and water efficient. We did discover one–the U.S. District Courthouse–with the help of Mr. Nazario. The building was renovated in 2000 and had some minor changes done to it, which produced energy savings. The lighting was changed to use fluorescent fixtures, and the air conditioning was updated to run more efficiently. We noticed that some of the most important changes were simple energy saving habits. The building utilized natural light wherever possible and kept lights off when they were not needed. It also only had air conditioning running in offices, courtrooms, and bathrooms; the hallways and public areas did not have air conditioning since most of the cool air would have escaped and caused the system to run inefficiently.

4.4 Water Conservation

While water consumption in the two buildings is not high, there is the potential to reduce this amount. None of the buildings we discovered in Old San Juan was practicing any large-scale water reuse methods. This meant that we had to analyze our observations of the Trust's building and compare the observations with published research.

The main factors that go into the decision to use a large-scale water reuse system are the building size and structural capacity as well as availability of sources for reuse. Walking through the two buildings, we discovered that they are relatively small buildings with only two main floors each. Casa Ramón Power has two floors, plus a flat roof, and Banco Español also has two floors, with a basement and flat roof. Casa Ramón Power has little room for water storage tanks, only room for small tanks in the patio. Banco Español has more room, especially in the basement. The small building size reduces the feasibility of many large-scale greywater and wastewater reuse systems, as they need large communities to work. Either building would need to be checked to be sure it is structurally sound wherever the water storage tanks would be located, especially if they were to be put on the roof.

The Trust's buildings have few sources for reuse, since they are office buildings. They do not own any land around Banco Español or Casa Ramón Power. Without land there are no lawns to water. Irrigation is one of the main uses for greywater and wastewater reuse. This means that the Trust has no uses for recycled wastewater, and can only use greywater for toilet flushing. Rainwater still has a number of uses; the Trust can use rainwater for toilets, washing, and with enough treatment, as potable water.

While neither a large-scale greywater nor wastewater system is feasible for the Trust, a rainwater harvesting system may be. Given the annual rainfall and the size of the roof, we can calculate the potential supply of rainwater.

$$\text{Supply} = \text{annual rainfall} * \text{roof area} * \text{efficiency}$$

The efficiency of the system depends on the materials and make of the system; a flat cement roof has the efficiency of 0.6, but aluminum or tile roofs have a higher efficiency of almost 0.9 (Worm & van Hattum, 2006, p. 31). With a modest, 0.75 efficiency, the Trust could collect 58,540 gallons per year at Casa Ramón Power.

$$\text{Supply} = (\frac{59.43 \text{ in}}{\text{year}} * \frac{1 \text{ ft}}{12 \text{ in}}) * 2,184 \text{ ft}^2 * 0.75 = \frac{8,112 \text{ ft}^3}{\text{year}} = \frac{60,682 \text{ gallons}}{\text{year}}$$

The current demand for water in Casa Ramón Power is 71,960 gallons per year. Given the supply, a rainwater system could provide nearly 81% of the building's water use, potentially saving the Trust almost $1,000 a year. However, we do not recommend installing a rainwater collection system at

Casa Ramón Power. The major reason for this is the lack of space for water storage tanks. There is a little room on the patio, but the historical feel would be impacted. Small storage tanks would reduce the effectiveness of the system, especially during the dry season. Additionally, the building is not scheduled for major renovations at this time, which would make it difficult to modify the plumbing to accommodate rainwater. The Trust could install a small rain water system that is mostly for educational purposes. The small system would consist of a small collection tank, with only one bathroom using it.

At Banco Español, the Trust could collect 111,142 gallons per year.

$$\text{Supply} = (\frac{59.43 \text{ in}}{\text{year}} * \frac{1 \text{ ft}}{12 \text{ in}}) * 4,000 \text{ ft}^2 * 0.75 = \frac{14,857 \text{ ft}^3}{\text{year}} = \frac{111,142 \text{ gallons}}{\text{year}}$$

With a predicted 45 people using Banco Español, a rainwater system could supply 55% of the water, saving the Trust $1,440 a year. We recommend that the Trust look into a rainwater harvesting system for Banco Español. There is plenty of room for water storage tanks in the basement of the building. Part of the renovations to the building would need to include modification to the gutter and plumbing system.

Since most of the Trust's water use occurs in the bathroom, most suggestions for improvement are located there as well. Casa Ramón Power has standard toilets and urinals, and replacing them with lower- or no- flush models would significantly reduce the amount of water used. Banco Español is in a position for complete renovation. This means that any existing water fixtures are due for replacement. As Banco Español will be an office building, we know that the Trust's main water needs are sinks, toilets and urinals. There will be many offices in the building, so the bathrooms will get more use. This will make it even more important for the bathroom fixtures to be water efficient. The Trust can use water fixtures with at least 20% less water consumption by looking for the WaterSense label. The WaterSense website (www.epa.gov/watersense/) has a product listing of available fixtures.

Using a WaterSense toilet is estimated to save 4,000 gallons of water per year. The toilet will save the Trust around $68 dollars a year per toilet. If they buy a mid-price model at $600 the toilet will pay for itself in 9 years. A WaterSense urinal is estimated to save 4,600 gallons of water per year, and waterless model saves twice that. WaterSense and a waterless urinal will save the Trust $78 and $156, respectively, per year per urinal. A mid-price urinal will pay for itself in 7 years and a waterless one in 3 years. The calculations are summarized in Table 4 below.

While a large-scale greywater system is not feasible for the Trust, a small system would be. AQUS is a greywater system that connects the bathroom sink to a toilet. This would reduce the amount of potable water used to flush the toilets, by reusing water. Each unit saves around 5,100 gallons of water (AquaPro Solutions, n.d.) and $87 per year per unit. With an initial cost of $200, a unit would be paid off in 2 years.

Table 4: Bathroom Fixture Savings

	WaterSense Toilet	**WaterSense Urinal**	**Waterless Urinal**	**AQUS System**
Initial Unit Cost (Mid-Price)	$600	$600	$500	$200
Water Saved per Unit (gal/yr)	4,000	4,600	9,200	5,100
Money Saved per Unit	$68.00	$78.20	$156.40	$86.87
Units in CRP	6	3	3	4
Units in BE	10*	2	2	6
Total Savings	$1,088	$391	$782	$869
Paid Off In	8.8 years	7.7 years	3.2 years	2.3 years

*Based off one Dec. 2009 floor plan; another shows only 6 toilets.

4.5 Education

In this section we present the potential educational opportunities for the Trust's staff and the public, based on the analysis of the building occupants' habits and the methods that the Trust and other organizations have been using for promoting energy and water conservation knowledge.

4.5.1 Educating the Trust's Staff

In order for the Trust to become a role model for energy and water efficiency, they must start at home. We found that, in general, the Trust's staff members have good energy and water consumption habits. However, we noticed there are a few areas in which they could improve energy and water conservation.

Sixty percent of the staff members could come up with energy and water conservation methods for their homes, a few of which are transferable to the workplace. Some examples include turning off devices and lights when not needed, and using energy efficient devices.

All interviewees who used a desk lamp responded that they turn off their desk lights when they leave, but most interviewees do not use one. Those who said they don't turn off the lights mentioned that they cannot do so due to the central lighting system. All of the staff we interviewed were good about turning off their computers at night, or using the sleep or hibernate function. Habits with respect to their computer monitors were not as exemplary; only 60% said they turn off their monitors when they are away from their desk for lunch.

While the staff we interviewed had good habits regarding lights and computers, they leave other devices on when not in use. In particular, we found that printers were left on all the time. One staff member was concerned about the printers being left on overnight, and another mentioned numerous devices that are plugged in in their office space that are never used. Many devices never turn off, but go into a stand-by mode. These devices continue to pull power while waiting to be activated.

The building at 201 Tetuán Street has a central air conditioning system, so no one can turn off the AC to their space when they leave the office. However, one interviewee believes that the last person to leave turns it off. In Casa Ramón Power there are individual AC units. Of the six interviewees in that building four turn off the AC units at night. The other two cannot due to the contents of the room - one is an archive and must be kept at 65 °F, and the other is the computer server room, which must also be kept cool at all times. One interviewee leaves his/her window open with that office's AC unit turned off, but said that it's difficult to keep the door to that office closed to prevent the AC units in other offices from being affected.

Habits and preferences regarding hand drying vary, but 90% of the interviewees responded that they use 1-3 paper towels to dry their hands after washing them in the restroom. Only one interviewee dries his/her hands by shaking them or wiping on clothing. Half of the staff dislike air driers for various reasons, air driers may not be a good replacement for paper towels. Furthermore, conserving the use of paper towels can also be a good topic of education for the Trust's staff.

4.5.2 Educating the Public

The Trust already knows how to educate the public about nature preservation; what the Trust does want to know is how best to publicize and educate the public about the steps it is taking and has taken in making its buildings more energy and water efficient. All of the people whom we interviewed agreed that it is important to educate the people of Puerto Rico on water and energy efficiency. Architect McCullough believes Puerto Ricans are willing to accept the green movement, but they lack education about what to do. If the Trust were to make improvements to their water and energy efficiency, it would be very advantageous for them to also inform the public about these conservation methods.

One method McCullough agreed with was to display any energy or water conservation steps that the Trust takes. To do so he suggested that the Trust should show in a poster or display, the savings that any renovation or new device provides. For example, if the Trust changed their light bulbs, they should make a display on the savings that the light bulbs offer and the life span of the light bulbs. Displaying this information would show the public not only that the Trust is taking steps to help preserve the environment, but it would show them ways that they could conserve energy and water themselves, while receiving a monetary benefit.

Engineer Carlos Rodriguez of FEMA explained that the Coalition of Engineers in Puerto Rico perform frequent trainings on technologies such as solar power. He also stated that there are a couple of technological universities that train and certify people for solar panel installation. He recognized that solar panels are gaining popularity in the area because the government has started a movement with their incentive programs for buildings that are energy efficient and utilize alternative energy sources.

Aireko Enterprises has experience with educating the public about the work that they do both for self-promotion purposes and to teach about environmental conservation. In their office they display an LCD screen showing the total energy consumption of the building (see Figure 7). It also shows the savings that were gained by using the solar panels on their rooftop. The data are calibrated to the hour so an observer can see energy trends from day to day in real time. The display teaches the members of the company to conserve energy as well, as they are reminded that their energy usage is being monitored. The screen also displays to anyone who visits Aireko Enterprises the efforts that they have taken to preserve the environment.

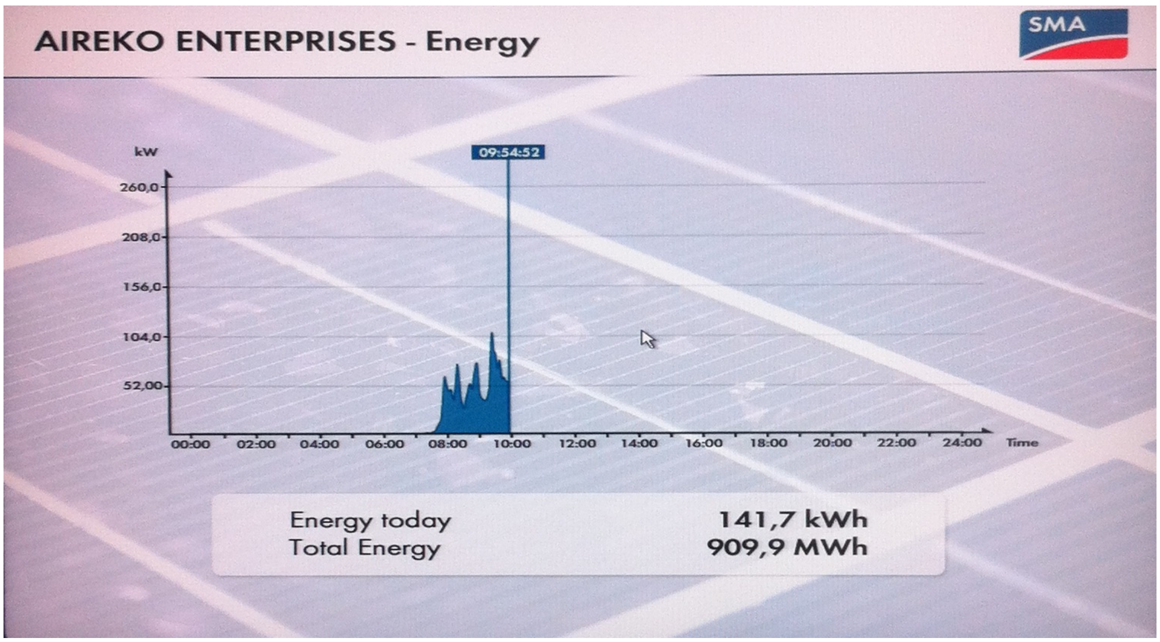

Figure 7: Aireko Enterprises - Energy. This figure demonstrates an LCD television displaying the energy usage at Aireko offices (Photo taken by Shaine Grogan).

Casa Ramón Power already has exhibits that educate visitors on nature. Our suggestion is that for any renovation or change made in the buildings the Trust create a display. One of the exhibits in Casa Ramón Power could display the efficiency of a device, and the monetary and energy savings the device offers. For example, they could exhibit the light bulbs they use in the buildings and their lifespan in comparison to other types of light bulbs. If the Trust installed an alternative energy source, such as solar panels or wind turbines, they would serve as a role model of energy efficiency. It would then be important that the Trust demonstrate and educate on how they are saving energy that is coming from fossil fuels. They could accomplish this by installing a LCD screen that shows how much energy is currently being generated. We suggest that the Trust install the same LCD Aireko has with the total energy consumption of the building, broken down by hour. The display would show any visitor that the Trust is very conscious of their energy usage. Another exhibit could explain the fixtures installed in the bathrooms, with how much water they save. Visitors could be invited to use the facilities, where additional signs could be placed. If rainwater is used, signs should be placed informing everyone that the water they are about to use is recycled and filtered rainwater. All of these exhibits will inform the public about how the Trust is conserving energy and water. When possible, the exhibits should be interactive. If the Trust installs an alternative energy source on the roof of Casa Ramón Power, they should invite the visitors up to see it. Visitors should be encouraged to enter the bathroom so they can see the greywater system, if it has been installed. To reach even more people, the Trust should have an online exhibit. The exhibit should explain the changes the Trust has made, and it should be updated periodically with the progress being made in energy and water conservation. The Trust could also have links to sources of information that visitors could use, such as ENERGY STAR and WaterSense.

5 Conclusion and Recommendations

We have combined the results of observations, archival research and interviews with our background research and have identified ways that may help the Trust to become more energy and water efficient and model their accomplishments to the public, all while preserving the historic integrity of their buildings. As the two buildings have different needs and capabilities, recommendations are distinct for each building, so we discuss them separately.

5.1 Casa Ramón Power

The Casa Ramón Power building and its occupants should take steps to conserve energy. It is important that the occupants of the building are educated and made more conscious of ways to limit their energy usage. One thing that we observed was that the buildings in Old San Juan are designed to utilize natural ventilation, yet it was apparent that this was not being used as effectively as possible since the offices require air conditioning. It would be costly to change the Heating Ventilation and Air Conditioning (HVAC) of the building and difficult to avoid alteration of some of the historic features of the building. The best option would be to ensure use of air conditioning only in areas where necessary as well as to ensure that the area is properly insulated. Currently the air conditioning is on very high in the offices, but doors and windows are open such that the cool air is traveling directly outside to cool the streets of Old San Juan.

With the high energy consumption and smaller roof area of the Casa Ramón Power building, it does not seem likely that solar panels would be cost effective for this building. We estimated that the system would only be able to cover 18% of the building's energy consumption. This estimate is based on the current state of the building; however if the energy used in Casa Ramón Power can be decreased to more reasonable levels, a PV system could be reconsidered.

5.1.1 Wind Power

For Casa Ramón Power, we explored installing a 10 kW wind turbine to harness the powerful coastal wind. The total cost of this turbine would be about 46,770, or $4,677 if accepted into incentive programs. A turbine of this size could produce about 20,000 kWh, or $5,400, of energy per year, which is 11% of Casa Ramón Power's annual consumption. As with solar power, we would suggest considering a wind turbine only if the Trust is able to lower energy consumption in the building. Alternately, the Trust could also look into installing two wind turbines, which would double the costs but also double the energy output.

5.1.2 Lighting and Devices

The lighting is one area that we found to be energy efficient. The light bulbs are energy efficient CFL's (Compact fluorescent lamps) and fluorescent bulbs that are ENERGY STAR rated. The building uses a great amount of natural light. Efficiency could further be improved by changing the lighting to individual controls instead of the central control that is in current use. This would allow the members of the Trust to shut off unnecessary lights, due to the natural light or lack of occupancy, and this would be especially beneficial for hallways and open areas on the second floor. Most devices used in Casa Ramón Power are energy efficient. However, the printers to occupants ratio is as high as 9:15. Relocating the printers to reduce the number of printers in use will improve the efficiency of energy use as printers are major energy consumers in the building. Furthermore, unplugging devices at night will also be beneficial.

5.1.3 Water Reduction and Reuse

Casa Ramón Power has recently been renovated, and no major renovations are planned. This restricts what can be done to reduce and reuse water. We do not suggest any large-scale water reuse system, as the building does not have enough space to support one. Instead, we recommend replacing toilets and urinals with ones that use less or no water. Replacements can be made with minimal adjustments to the current plumbing in the building. A small greywater system, that connects bathroom sinks with toilets, would require some additional changes to plumbing, but not a large renovation. Additionally, the Trust could consider a rainwater harvesting system, with only a small water storage tank, mostly for educational purposes.

5.2 Banco Español

The Banco Español building is not currently in use and needs a complete renovation, so the Trust has many options to make the building more energy efficient. Changing the mechanical systems of the building would be the major way to save energy. An HVAC retrofit has many options to conserve energy such as a BMS (Building Monitoring System) system and automatic controls. These sensors detect when a zone or room needs more or less air or requires an increase or decrease in temperature; it can shut off air conditioning when rooms are not occupied. Double-pane-glass windows with higher U-factor and SHGC value and lower air leakage rating will add to the performance of the AC system as they have better insulation value. We suggest that the Trust shade the south, east and west facing windows using any possible methods, including curtains or awnings. An effective cooling system with good insulation will be very beneficial for both personal comfort and energy conservation. Furthermore, the system can be integrated with lighting controls to shut off lights of unoccupied rooms. The Trust would want to examine these options when they choose a construction company to perform the necessary renovations, as they can provide large energy savings and can have a short return on investment.

5.2.1 Solar Power

With a larger roof area than Casa Ramón Power, a PV system for Banco Español seems more feasible and cost-effective. We estimated that a 37 kW system would work best for the building. The system we propose would only take up a maximum of 3,040 square feet, so there is potential for expansion within the available 4,000 square feet area. We predict that a system of this size, using 245 kW solar panels, would cost $216,660, including other equipment and labor costs. We also suggest exploring government tax incentives, as they can drastically decrease the price of this project. From our research, we determined that this project could potentially be eligible for two programs: the Puerto Rico Green Fund and the Renewable Energy Grant. These two incentive programs combined could decrease costs to as low as $21,666 for the entire system. A PV system for Banco Español could cover almost 100% of the energy used in the building. This assumption is based on energy bills when only one floor was in use, however. After the building is in full use again, the PV system would still be very effective, producing 50,412 kWh, or about $13,600, of energy annually.

5.2.2 Wind Power

As with Casa Ramón Power, we considered a 10 kW wind turbine for Banco Español. The results of this analysis were the same as Casa Ramón Power's; this is because the wind is similar on each building's roof and the 10 kW turbine does not change. Again, the total cost of this turbine would be about $46,770, or $4,677 if accepted into both incentive programs. A turbine of this size could produce about 20,000 kWh, or $5,400, of energy per year, which is 40% of Banco Español's previous annual consumption. This is much better than the 11% for Casa Ramón Power, so we believe a wind turbine would be much more cost-effective for this building.

5.2.3 Lighting and Devices

The Trust should explore installing a new lighting system for Banco Español. We recommend CFLs or even LED light bulbs. Installing a sensor for specific zones or rooms of the building would ensure that lights are always shut off when the rooms are unoccupied. Another option would be to use a BMS that will monitor the amount of lighting and detect movement of people in the room. The devices of Banco Español will be the same as those in current use at the building on 201 Tetuán Street, the office space the Trust currently uses. The devices were mostly up to date and many were ENERGY STAR rated. The members of the Trust need to make sure that they are conscious about shutting off lights and other devices. There is a 14 to 25 printer to users ratio currently in 201

Tetuán Street. This ratio can be greatly reduced and many printers not in use can be unplugged. Educating the members of the Trust on ways to conserve energy would increase the energy efficiency when the Trust moves into Banco Español.

5.2.4 Water Reduction and Reuse

Banco Español is in need of major renovations, allowing more possibilities for water reuse. While the building still is not big enough for a large-scale greywater or wastewater system, a rainwater harvesting system may be feasible. The roof is large enough to supply at least 55% percent of the predicted water needs. While renovating, the plumbing system could be adjusted to support the rainwater system. As with Casa Ramón Power, we suggest installing low- or no- water use toilets and urinals, as well as the small greywater system that connects sinks with toilets.

5.3 Education

This section covers our suggestions for educating the staff members and ways to educate the public.

5.3.1 Staff

We suggest that each Trust member:

- conserve paper towels, using 1-2 sheets per time instead of 1-3 sheets;
- set the computer such that when people leave the desk for more than 10 minutes, the computer will change to sleep mode or shut down mode automatically;
- turn off the monitor when leaving the desk;
- unplug the commonly used printers at night and the printers that are not in use;
- relocate the printers in the buildings to minimize the number of printers in use;
- leave the lights in the exhibition room off when there are no visitors there.

By promoting the above habits the Trust will be able to avoid unnecessary energy use. Furthermore, these changes in habits can also be advertised to educate the public about energy conservation.

In addition to changing the current habits that we observed, the Trust will need to improve its energy and water management. We suggest the Trust adopt the strategy recommended by the ENERGY STAR program and use the ENERGY STAR's online Portfolio Manager to track the building's performance over time.

5.3.2 Public

To educate the public, we suggest that the Trust add a display for each renovation they choose to make. The display should explain how much energy or water is being saved. Whenever possible, visitors should be invited to see the renovation in action, for example inviting visitors to use the bathrooms. We also suggest that the Trust install a display with energy use broken down by hour, to inform visitors that the Trust is aware of the energy they use. We suggest creating a webpage that explains what renovations and changes the Trust makes, that is updated periodically and has links to online tools that others can use.

5.4 Conclusion

We based all of our recommendations on the detailed analysis of the current condition of energy and water consumption through observations and archival research, interviews with professionals, interviews with the Trust's staff and background research on energy and water conservation topics. By adopting our recommendations regarding renovations as well as energy and water management, the Trust will be able to conserve energy and water while also making the offices more comfortable. Considering and adopting some or all of our recommendations for educational purposes will aid the Trust in advertising the work they have done and will do with respect to energy and water conservation and will create interest in saving energy and water in the general public.

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Appendix A: Sponsor Description

The Conservation Trust of Puerto Rico (the Trust) is a private, non-profit organization with a mission to protect and enhance the natural resources of Puerto Rico (Conservation Trust of Puerto Rico, 2007). The mission has been realized through the acquisition and donation of land with high ecological importance or historical value. Currently only seven percent of Puerto Rico's land is conserved compared to the thirty-four percent of the rest of the United States. The Trust aims to improve the situation in multiple ways, including but not limited to public education on environmental issues and the need to protect and conserve natural resources. Among the Trust's many efforts, *Árboles más árboles (A+A)*, a reforestation program, produces and distributes native tree species that promote the island's biological diversity. The only beneficiary of the Trust is the people of Puerto Rico.

In 1970 the United States and Puerto Rican governments founded the Conservation Trust of Puerto Rico to protect and enhance the island's natural resources (Conservation Trust of Puerto Rico, 2007). For the first ten years the funding of the Trust came from U.S. tariffs paid by the petrochemical companies operating on the island. The Trust then began to generate income through private financial transactions. After that it invested in stocks and bonds which helped to generate the Trust's own income for acquiring land of high ecological and historic value. Funding is also received from the Trust's AMIGOS, who are individuals and corporations committed to the protection and conservation of the natural resources and beauty of Puerto Rico. These financial mechanisms allow the Trust to support its different efforts, including its most urgent one: the protection of natural areas and their conservation.

The Trust's income allows it to support a range of efforts in protecting and preserving Puerto Rico. The most important effort is the protection of natural areas for conservation. The architect Francisco Javier Bianco led the Trust in protecting 16,000 acres of land at Parguera in Lajas, Las Cabezas de San Juan in Fajardo, Hacienda Buena Vista in Ponce, Hacienda La Esperanza in Manatí, and many more areas all over Puerto Rico. Mr. Bianco also directed historic restoration projects which included the Trust's headquarters at the Ramón Power and Giralt House in Old San Juan. Mr. Bianco retired in December 2002, and the lawyer Fernando Lloveras San Miguel succeeded him as Executive Director of the organization. Recently, with Mr. Lloveras as the leader, the Trust has acquired over 2,000 additional acres of land. Mr. Lloveras was also responsible for the reforestation program's native tree species production. He is also responsible for moving forward a collaborative initiative among multiple government and educational entities focused on biodiversity conservation in Puerto Rico (Conservation Trust of Puerto Rico, 2007).

The Trust consists of the Executive Director, the Board of Trustees and the Advisory Council. The structure can be visualized in Figure 8.

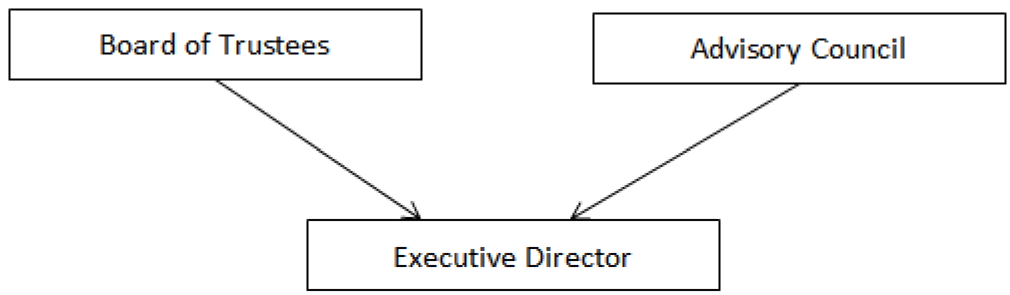

Figure 8: The management structure of the Conservation Trust of Puerto Rico. This picture illustrates the management hierarchy of the Trust.

Currently the Executive Director, Fernando Lloveras San Miguel, oversees all projects and activities of the organization (Conservation Trust of Puerto Rico, 2007). The Board of Trustees, which manages the organization, is made up of several innovative individuals, including Kate Romero, Mack Mattingly, and Maria Lorenza Ferre Rangel. The Advisory Council is composed of many professionals, each specializing in one part of the organization's mission to conserve Puerto Rico's natural beauty, resources, and historic areas. The organization has only about 15-20 employees but receives substantial help from volunteers.

Appendix B: Room Sheet

Building:

Room:
Number of Occupants:
Number of Windows:

Lighting:

Type	Energy Use	Replacement	Number	Other

Devices:

Type	Brand	Model	Age	Condition	Energy	Water	Number	Other

Appendix C: Interview Protocol: Construction Professionals

Description of our project:

The Conservation Trust of Puerto Rico owns two historic buildings located in the Old San Juan district that were built in the 18th and 19th centuries. They are currently not as environmentally friendly as they could be. The Trust would like to improve the energy and water efficiency in these buildings while still preserving the their historic character. The goal of our project is to recommend modifications that can be done to the buildings to make them more energy and water efficient while preserving the historic character. Our objectives are as follows: identify different types of alternative/efficient energy sources and water conservation/reuse methods, determine electrical and plumbing replacements that reduce consumption, and provide suggestions for renovations and education on energy and water conservation.

Agenda of Questions:

1. Would you briefly describe what your company does? What is your position at the company and what are some typical responsibilities you have?
2. What experience do you have with renovating old buildings, while still preserving the historic character? What are some of the factors that have to be considered when planning a project like this?
3. How much can zoning laws and regulations restrain a project? Are there any specific zoning laws in Puerto Rico, for Old San Juan specifically, that might relate to our project, and that we should further examine?
    (a) Do you know where we could find the zoning laws for Old San Juan? (in English, if possible.)
4. How often do you consider energy and water efficient products when designing or building a structure/building? What products have you used that you think are good and why?
    (a) What kinds of energy/water saving devices do you have experience with? (i.e., energy efficient light bulbs, lighting controls, HVAC systems, low flow toilets, faucets, etc.)
5. Do you find any of these devices more effective than others? Less effective than others? Why?
6. Have you ever been part of a project where alternative energies are used? (e.g., solar panels, wind turbines, rainwater recollection, etc.)
7. What is your opinion on these technologies and do you see them as viable options for the future of energy and water conservation in buildings?

8. In your opinion, what is the Puerto Rican population's view on green products and alternative energies?
9. We will be trying to educate people on energy and water conservation. Do you have any suggestions on ways to encourage people into becoming more efficient with their energy and water use?

Appendix D: Interview Protocol: Occupants of the Buildings

Description of our project:

The Conservation Trust of Puerto Rico owns two historic buildings located in the Old San Juan district that were built in the 18th and 19th centuries. They are currently not as environmentally friendly as they could be. The Trust would like to improve the energy and water efficiency in these buildings while still preserving the their historic character. The goal of our project is to recommend modifications that can be done to the buildings to make them more energy and water efficient while preserving the historic character. Our objectives are as follows: identify different types of alternative/efficient energy sources and water conservation/reuse methods, determine electrical and plumbing replacements that reduce consumption, and provide suggestions for renovations and education on energy and water conservation.

Agenda of Questions:

1. Do you feel comfortable with the room temperature/ cooling system of the current building in which you are working? If not, could you please specify your suggestions about how the conditions could be improved?
2. Do you feel comfortable with the current lighting in the building? If not, could you please specify your suggestions for improvements?
3. Do you feel comfortable with the facilities in the restroom? If not, could you please specify your suggestions for improvements?
4. Are you familiar with any energy or water conservation methods? If yes, could you please specify how you usually save energy and water at work or at home?
5. Do you have any of the following habits at work?
   (a) Turning off the lights/lamps when leaving the office
   (b) Turning off the computer/monitor when you are going to be away from you desk for an extended time period
   (c) Opening the window when the air conditioner is still on
   (d) Turning off or down the air conditioner at night
   (e) How often do you use the elevator (if there is one) every day? Do you ever use the stairs to travel between floors?
   (f) How do you dry your hands after washing them at work? At home? Do you like air driers? Why or why not?
6. Do you have any opinions on any of the buildings regarding energy and water that we haven't covered already?

Appendix E: Interview Protocol: Communication and Education

Description of our project:

The Conservation Trust of Puerto Rico owns two historic buildings located in the Old San Juan district that were built in the 18th and 19th centuries. They are currently not as environmentally friendly as they could be. The goal of our project is to recommend modifications that can be done to the buildings to make them more energy and water efficient while preserving the historic character. Our objectives are as follows: identify different types of alternative/efficient energy sources and water conservation/reuse methods, determine electrical and plumbing replacements that reduce consumption, and provide suggestions for renovations and education on energy and water conservation. We intend to gather detailed information of education and communication to form our recommendations to advertise and promote the Trust's actions in energy and water conservation.

Agenda of Questions:

1. We understand that one important part of the Trust's work is to educate the public about conserving the environment and natural resources. Generally speaking, who is the audience for the Trust's education campaigns? How many people do you estimate you reach with your education campaigns per year?

2. What kinds of educational approaches have you used in trying to educate the public? How effective have they been and how have you measured this? What has been the audience's feedback?

3. What kinds of educational approaches have you used in trying to educate the public? How effective have they been and how have you measured this? What has been the audience's feedback?

4. What suggestions do you have that you think would best promote the Trust in being a role model in conserving energy and water in buildings?

Appendix F: Interview Transcript: Griffin Electric

Interview Transcript: Steve Magill and Wayne Griffin
Date: February 11, 2012
Location: Wayne J. Griffin Electric headquarters in Holliston, MA
Participants: Wayne Griffin (President), Steve Magill (Senior Project Manager), Kevin Griffin (Chair), Shaine Grogan (Secretary)

We started out by introducing ourselves then jumped right into questions:
(Some answers have been cut down, so only relevant information is present.)

Shaine Grogan: Can you start off by giving us an overview of what Griffin Electric does? What exactly does an electrical subcontractor do?

Steve Magill: Basically, our line of work is to only build electrical construction. We are almost always contracted through a general contractor; we do very little work directly for an owner. As a subcontractor, we do not really go outside our realm of electrical work: electrical, security, telecommunications, and fire alarm. Like a lot of construction trades, our electricians must all be licensed through the state. In order to become an electrician in Massachusetts, you have to work a minimum of 8,000 hours, or four years, and also go to schooling for 125 hours. They do this primarily to ensure safety and quality of work, because when the nature of electrical work is done wrong, it can not only hurt the electrician, but also the end user of the project.

Kevin Griffin: I'm not sure if you got to read our brief project description, but basically [explained project]. How important is the energy efficiency in the electrical infrastructure of a building? And what are some of the benefits of installing efficient systems?

SM: Well obviously, cost and energy-saving costs is the easiest one to address. I believe that in Puerto Rico, both water and electricity are quite expensive. I think that compared to here, you might find it off the charts. What we find when addressing energy efficiency, you can't just make one system efficient and not the other. For example, say someone puts in an energy efficient heating or cooling system, but the air handlers that are blowing the air are not driven by variable frequency drives. The electrical losses will cut into the mechanical gains. Also, for electrical, lighting is probably the single biggest waster of electricity. Controlling lights with both energy efficient lighting and automatic lighting controls, to turn things off in unoccupied spaces or at certain times of the day, work to conserve electricity. The other thing that happens is anything using electricity releases heat, which causes a greater heat load in the building, and requires more cooling to offset it. And I'm guessing the cooling is more important than the heating in Puerto Rico. So, if you make one system efficient, you do better. But if you do it across the board with multiple systems, you can lower your energy consumption more drastically, because as you get more electrically efficient, you require less cooling, so it just gets better and better. SG: What are some of the most affordable and effective green technologies that Griffin Electric has installed? Or seen installed?

SM: Almost every single building we build has high-efficiency motors, motor control, variable frequency drives, lighting, occupancy sensors, and plumbing and heating controls. They actually go so far with some of the newer sensors on urinals, if you stand in front of it for under 60 seconds, it will flush a gallon of water when it flushes. If you stand there, for more than a minute, it will flush 1.8 gallons. So most of those toilet sensors will actually flush more water the longer you are there. So little things like that make a difference when you have hundreds of thousands of uses per year in a public building. Heating controls and occupancy sensors are being seen a lot more now in bathrooms, locker rooms, kitchens, and places like that. Kitchens that have exhaust systems with big fans, which typically run 24/7 in occupied spaces, now are being integrated with the lighting control occupancy sensor to turn the fans off when the room is unoccupied. And they may even lower the temperature controls in some rooms depending on the building and the type of heating system. There are costs that come along with these though; the more you control, the more upfront costs. Geographic location has a major impact on the effectiveness of these systems, too. You are going to focus on what it will cost in Puerto Rico, rather than here in the Northeast, where it's almost totally opposite. Cooling in Puerto Rico will be very important. Depending on the size and occupancy of a building, heat will be created because of the moving bodies and more cooling will actually be needed. I think the biggest "green" product that we see installed that people don't like are waterless urinals. Sometimes people are forced to put them in to get LEED, or think they will be water saving, but they just don't work. They cause lots of maintenance problems, and obviously they get an unpleasant smell. It's really not the benefit that people want.

KG: What are your opinions on alternative energies, such as solar and wind power? And do you see these as viable options for a future where fossil fuels are sparse?

SM: I think that eventually, they'll have to go there. But right now, it's difficult to make them financially feasible in many applications. Without the government assistance that is provided on most of these, the numbers just don't work. The other thing that is going to take some getting used to is the aesthetic impacts of solar panels, windmills, and items like that; they can be very unsightly. The other thing that people don't look into, with solar panels in particular, is the impact on the environment. They have a very severe impact on the environment from a manufacturing standpoint and also from a disposal standpoint. Just like batteries and other similar devices, the major concern is what do you do to dispose of these things? Another thing we find that people aren't looking at is the effect on the architectural structure of a building. When you load up a rooftop or something like that with solar panels on a rack, it is depressing the insulation and roofing material and could damage the structure. Some people are putting structural steel directly through the roof to support the panels, which creates hundreds of penetrations that could possible failure points, which could allow leaks, insects, or anything through. Also, if you need to repair the roof, you first have to remove the solar panels, so now you have an added cost. The other thing is the panels typically have a 20 year lifespan, so you have to look at what it's going to do, how it effects the building, and when you take the panels off in 20 years, are you replacing the roof 10 years early because you don't want to have to coordinate the panel removal repeatedly?

SG: What are your thoughts on the LEED certification program? Do you think it can be an effective tool to become a more efficient community?

SM: They keep making the LEEDs more and more stringent. From an electrical contractor's point of view, there are very few LEED points that directly affect us. Lighting and lighting control, but those should be built into every job, regardless of LEED or not, because from an energy standpoint, you wouldn't want to build a building without them. The trash removal is a big one, but from an efficiency standpoint, we try to do those same things. Like with light fixtures, we try to order them without cardboard boxes on them; we want them palletized and shrink-wrapped. Selfishly, not because we are worried about the environment, but it's just added labor to get rid of the cardboard casing. Those things have obvious beneficial impact. There are other things, I don't have the term in front of me, but measurement and control is when we start metering loads inside a large building and find which piece of the building is using how much electricity. But again, there's a lot of money upfront to do that, and you have to ask, is the client going to use that? It might be nice to have, but are they ever going to do anything about the information it gave?

KG: Do you think the government incentives they are offer for all these green products are worth it? And do you know what kinds of incentives are available?

SM: Wind and solar incentives are the only way for the private to work, and they are definitely worth-while. There is some move in the industry, and you've probably heard some commercials on the radio about how you can sign up to put some solar panels on your house and basically pay a thousand dollars. Well what they are doing is those companies are getting the credits from the government, and they are taking the credit value back, signing you up to a short-term lease, and once that lease is gone, then you'll be on your own to buy them at a higher value. Those credits are coming from the utility companies who have to pay penalties for burning other types of fuel. So what you're seeing is a lot of the utility companies are building solar panel and wind farms not because they care about solar panels and wind farms, but they want to offset their negative credits. A lot of these programs are setup for good reason, but they get manipulated, too. If you're talking about Puerto Rico, solar panels and windmills might be much more effective there. In San Juan, I would imagine it's windy there all the time, being an island like it is. And obviously there is much more sun than up North; typically the more north you come, the less effective solar is. Your financial examples may work much better there than they would here.

SG: How much can an outdated electrical system affect the costs to an owner?

SM: We think the single biggest thing we see is inefficient lighting. Like I said earlier, the heat it creates and then extra electricity it consumes are two of the biggest issues. Obviously, LEDs are probably the future; they just still aren't quite there yet. You can get almost as good as the LEDs with the high efficiency fluorescent lighting. The biggest drawbacks to these are color and cost. People are used to certain comfort levels of colors of light, and you don't have as much control over the color of light with these systems. The actual wiring can make you a little more efficient, but again, it's more related to mechanical upgrades that are electrically driven, so it's kind of a mechanical/electrical answer.

KG: How much renovation experience does Griffin Electric have with older buildings?

SM: For the most part, we provide a variant amount of new work and remodel. And for the most part, every renovation job that we work on contains energy upgrades. You would have to be crazy to renovate without these upgrades. That's how they tend to fund some of these; if you're going to spend two million dollars renovating, you hope to recover a portion of that cost in long-term energy savings. So it's really involved in every project we do, as far as energy upgrades go, and that, again, can include a lot of things. Some of them can be architectural, like how you're insulating things, and it's not just better motors but also windows, doors, etc.

SG: Have you ever worked on a historical building, and does it affect how you approach the construction?

SM: It can be a very big problem sometimes. We usually ask, "What can't be touched in the building?" So say you walk into a building that has a historic lobby with vaulted ceilings, to try and retrofit that with the latest LED lighting or fluorescent lighting, the architects are not going to want that. It's going to lose its flair, so that can be a challenge. Some of the things we talked about, like wind farms and solar panels, they don't really like to put them on top of churches, and things like that. You can probably still do the mechanical systems, but they have to be hidden somewhere. There has to be some effort put into how you are going to handle that. There has to be some give and take, because most of these buildings are not setup to architecture acceptance.

KG: What suggestions can you give us that will help us to evaluate the two historic buildings we will be working on? What kind of approaches can we use to determine how efficient the buildings are now? How can we evaluate which energy efficient methods and devices will work on these buildings?

SM: Whenever we attack a job, even when building new construction, we are going to want to know, where is the cost? Where is the biggest cost? From their standpoint, you want to look at, what's your energy consumption now? If it's really old, they might not have that much energy consumption, but maybe they don't have the features they want. That can be difficult to evaluate: are they just trying to restore the building to what it was, or are they trying to restore it and put modern systems in it? Sometimes, you are going to end up with a more expensive building, because it might not have originally had air conditioning but want to put it in. You want to look at hours of operation, architectural sensitive areas, and current utility usage. Is there real estate for high-efficiency systems in ground, such as water systems, geothermal systems, ground wells, and wind and solar equipment? Can any of these be put on the property and still maintain the historical character?

Wayne Griffin: So if they have a meter bill, utility bill, or any kind of relevant bills, that invoice or billing per month tells you how much dollars and how much kW (kilowatts), which is the electrical usage. And then how much per dollar per kW, so it's simple math. This kind of information can help you determine the costs and savings of your recommendations.

SG: We will be trying to educate the community on efficient habits and products to be used. Do you have any suggestions on a way to intrigue people into becoming more efficient?

SM: It's hard, obviously, to get anybody to do something different than what they're used to doing. So, in the current world, it seems that people's electronic devices will keep them occupied. I'm not sure if there's some way you can get them to react through modern-day technology. Perhaps when you go by, your electronic device can help you learn something. That's part of the LEED training systems; a lot of these places have interactive kiosks that interest people and can affect their outlook on these matters. Certainly, financial incentives are an easy one, but you have to know if they are available and what kinds there are. Then you'd want to provide personal comfort. What are people going to gain by it? How is it going to make their lives better? We still have that challenge right now with solar and wind: there's still the person that wants to do it because it's the environmentally right thing to do, but they can't financially make it work.

KG: This interview has provided us with a massive amount of information, and I want to thank you for taking time out of your day to meet with us. We may reach out to you later in our project if more questions arise. Again, thank you.

Appendix G: Interview Transcript: Consigli Construction

Phone Interview Transcript: Matthew Burger, Consigli Project Manager
Date: February 16, 2012
Location: Kevin's apartment
Participants: Matt Burger (Project Manager), Shaine Grogan (chair), Kevin Griffin (secretary)

We started out by introducing ourselves and having conversation on WPI football. We then started talking about Puerto Rico and then moved to the questions that we had sent to Matthew Burger. *(Some answers have been cut down, so only relevant information is present.)*

Shaine Grogan: How was doing construction in Puerto Rico different than in New England?

Matt Burger: The pace of work is slower. There is way more people on a job to do that job, than back in New England. It is almost two guys to one, and is way more labor intensive. Labor work is used compared to machine work. Labor rates are way lower, as there are only loose union ties for truckers and steel workers. Other than that many laborers are making around eight dollars an hour. The climate is different. The last two years has had a lot of rain, which affects the construction. Typically, you are going to get rain 3 out 5 days.

SG: What exactly is your project? Did you do new construction or renovation?

MB: New construction they haven't done any renovation in Puerto Rico. Consigli came down in March 2010, with a job for the federal government working on the east side of Puerto Rico for the Army Core of Engineers. They recently finished that job and have two current jobs. One is an insurance claim job, the other is a design-build project. I am staying a few blocks away from where we are staying.

SG: What kinds of incentives are offered for these green technologies.

MB: I am not familiar with this info, but do know some architects that would be able to provide this information. One of his friends is located in San Juan and he would be able to provide us with this information. I will send you his contact information.

SG: Did you worry about being green? If yes, what energy efficient devices or alternative energies did you use?

MB: All three projects I am involved in are LEED projects. Two of them are LEED silver, and I believe the third is as well. We are implementing things like fixture lights, low-flow water usage in sinks, toilets, and plumbing fixtures. The newest project has photovoltaic ray that will power 80% of the electric use of the project. They have been working with grey water reuse in toilets. They focus on the filtration of the reuse to make sure that the water doesn't do things like leaving a grey mark on the toilets.

SG: Have you ever used water saving technologies?

MB: When it gets to the point of proposing renovations look at replacing plumbing fixtures for lower flow fixtures. Look at different lighting sensors or timers if people aren't occupying the space. Look at air conditioner timers also. These are things that you can put into use. Check out the energy use/water and the cost returns to come up with saving that these renovations would offer.

SG: What kind of reaction have you seen in the local community to green building? Do people support green building or think it's a waste of money?

MB: It is something that Puerto Rico is going to. On my project we source separate the construction waste and job site. Not as much of recycling is done in Puerto Rico than in Massachusetts, as they are behind, but it has started to pick up in the last four to five years. People are open to being green and it seems that it is beginning to move that way.

SG: Do you have any knowledge of zoning laws in Old San Juan?

MB: This goes along with the Puerto Rican government. I don't think you guys should really have a problem with this.

SG: We were thinking about seeing if a windmill would work in the area.

MB: I don't think realistically in that area you could put a windmill in. Across the bay where the cruise ships come in you can see that there are windmills over there. In Old San Juan the zoning requirements probably wouldn't allow a windmill. Thing you can look at are possible buying green credits, if they put a windmill in another area and feed the electric grid they may be able to get some electric credit.

SG: Do you have any idea of the current conditions of energy and water usage in Puerto Rico?

MB: Most of the buildings are CMU block, so not much framed or dry walls. You could look at the windows and possibility of putting in insulated energy efficient windows. See what types of fixtures, go online look up the model number. Examine fixtures that would use less water.

SG: We will be trying to educate the community on efficient habits and products to be used. Do you have any suggestions on way to intrigue people into becoming more efficient?

MB: Old San Juan is a tourist attraction where people go so maybe during construction put some signs up that the building is under construction to make it more energy efficient. Making the community aware of the steps to be more environmentally friendly is importantly to say. If we put new fixtures in a simple sign over the handle of the toilet should be used to show the water savings.

SG: Would it be okay if we contacted you for any information or contacts.

MB: Yes I think my friend Mark the architect could provide some helpful ideas. I will give him a ring and let him know you will be in contact with him.

SG: We are planning on meeting with him down there, would this be possible?

MB: He is very close it's probably a 3 or 4-minute drive. You could stop in and see him and his office. One of the girls that work with me she just did her masters on something identical to what you are proposing. Proposing renovations in Old San Juan to make them more energy efficient. Let me know if anything comes up feel free to shoot me an email about anything, I'm here I know the area so feel free.

Appendix H: Interview Transcript: Aireko Enterprises

Interview Transcript: Alex Nazario
Date: Thursday, March 29, 2012, 10:00am
Location:

Aireko Office
Las Casa Street, Lot #20
Bairoa Industrial Park
Caguas, PR 00725

Participants: Alex Nazario, Business Development Director, Aireko Enterprises; Kevin Griffin; Shaine Grogan

Kevin Griffin: Would you briefly describe what your company does?

Alejandro Nazario: We have been in business for 49 years. We are a general contractor or a construction manager and we self perform our civil, electrical, and mechanical. We have a division called AMS Construction Managers and Aireko Construction, which is the main part of the company. We want to be involved in all aspects of a project. In Puerto Rico it is doable to self perform electrical and mechanical, if you go to the States this wouldn't be possible due to competition. About 3 years ago we started getting into the Energy branch.

KG: What exactly do you do for the company?

AN: I am a business development director. I have been here for six years. I deal with preconstruction and keep involved with pretty much everything.

Shaine Grogan: What are some of the problems you face when renovating historic buildings?

AN: The biggest thing, especially in Puerto Rico, is the HVAC systems. If you talk to an engineer/designer on how to make a building more efficient with the changes of temperature, more than likely they are going to tell you to put insulation on the inside or outside of the building. However, in historic buildings you can't do this, so that is a major issue dealing with historic buildings.

KG: Can you briefly describe the scope of the Cuartel de Ballajá renovation project? What kind of challenges were faced during construction?

AN: That is where Marc Anthony and J-Lo got married. That's what you usually hear when you bring up that building, but it has a lot of history to it. Check out the powerpoint we have on it. (He showed us a powerpoint on the building.)

SG: How much can zoning laws and regulations restrain a project? Are there any specific zoning laws in Puerto Rico, for Old San Juan specifically, that might relate to our project, and that we should further examine.

AN: I'm not an expert on the laws, but anything to do with windmills will be very hard in that area. Any large windmill can be ruled out. It is a windy area, but you won't see a windmill there.

SG: What about the use of a small windmill?

AN: I am not sure, I can ask Hector. He is a general manager for the energy division that is an expert and has been here for ten years. The zoning laws probably just say you can't do anything, but I will ask Hector for you.

KG: Do you know of any other buildings in Old San Juan that have been renovated to be energy and water efficient?

AN: The hotel of Cubento, which got rebuilt about ten years ago. They used energy efficient lighting, but this project won't apply to yours as much as the Cuartel de Ballajá renovation project. The U.S. District Court in San Juan was also recently renovated. This was part of the federal projects restorations.

SG: How often do you consider energy and water efficient products when designing or building a structure/building? What products have you used that you think are good and why?

AN: Waterless urinals I personally don't like. They work as far as saving energy, but I think they stink. Water efficient systems can help to save water.

SG: What is your opinion of renewable energy systems? Do you think they are viable options for energy in the long run, because of the maintenance they require and how long they last?

AN: The PV system itself has a 20 to 25 year lifetime. The equipment, inverters, etc., I think, it's about 15 to 20 years. The return of investment that we're gonna get on this building, our office, it was predicted to be seven and a half years. That was based on a 75% tax incentive credit that we received. So if you're talking about doing a PV system, or any renewable energy system, without incentives, it might not be worth it since you're talking about 13 or 14 years for return of your investment. So when you talk about the tax incentives from the government for these system, it changes the picture completely. We got the 75% credit because it was the first run they did for incentives in Puerto Rico. Many people applied for the initial run of incentives, but never got them because their projects never happened. So it's something that you have to spend the money, and then you get the tax incentives. Now the way they are doing it, you got 60% on projects that are less than 100kW, and anything more than that you can get 50% credit. They do it by application process, so let's say they open July 1 for applying and you come in and submit your projects. It doesn't mean you're automatically going to get approved; they look at the projects and see which ones will have the best return of investment, and they're going to approve the best ones first. They have a cap of how much they can give out, so they want to make sure they can spread it throughout projects on the island.

SG: What is your opinion of the Puerto Rican population's view on being "green"?

AN: I mean you got both people that wanna see it and people that really don't care. It's really the same everywhere you go. I personally think it's a great thing, especially in Puerto Rico, since you don't have too many power generation plants. Even in St. Thomas, we're working there right now putting a PV system on a CostCo. Three years ago, when we began planning the project, it was about 30 cents a kilowatt, and now it's about 40 cents. So in places like that where energy is so expensive, you can get a return of your investment in 6 or 7 years, even without a tax incentive. So it is definitely worth it, but you have to have money to put these systems in place. I think that the banks should also be helping out with these kind of things. If the banks setup some sort of loan program, people would probably start to invest in these systems more for their homes.

KG: So one of the big parts of our projects is to think of ways to educate the public on the subject of energy and water efficiency. The Trust has multiple exhibits about their reserves and the environment, but they want to extend their teaching to energy and water conservation, too. Do you have any suggestions of ways to stimulate the interest of the public to educate them about this kinda stuff?

AN: If the Conservation Trust does these projects and during them, educate people what they're doing and advertise the steps they are taking. They have to keep it simple though and not get too technical, so that everyone understands it. And then when the projects are done, keep presentations throughout the buildings to show off "I'm using less water," "the rain we are getting is being recycled," "we have insulation that makes our A/C more efficient," things like that. They are actually doing this in the Cuartel de Ballajá project. One of our guys is putting together posters to explain the steps being taken in the building. So when you are walking around the building, you can see these explanations that shows what's happening and what's been happening with, for example, the PV system or the green roof. That's probably the best thing you can do.

KG: Can you explain the screen we saw outside in the lobby that was giving live information about energy consumption and the solar panels of the Aireko office building?

AN: That there is as easy as connecting a computer program to the inverter of a building. SMA is the brand of our inverters and they provide that program. All you need is an internet connection, and you just log onto Aireko SMA and all that information is shown. It shows the energy consumption for our office on a live, updating graph, along with the total energy consumption since the system was setup. It can also shows solar radiation, temperature at the surface of the solar panels, temperature of the environment, wind speed, carbon dioxide emissions to the environment, among other things.

KG: That kinda program sounds perfect for what the Trust wants to do. It would be great to have that in an exhibit to show off their energy savings. That's all we have for questions, so thank you so much for taking time to sit down for an interview.

Appendix I: Interview Transcript: Mark McCullough

Date: Wednesday, April 4, 2012, 10am
Location:

McCullough Domínguez Architects
Fernndez Juncos
San Juan, PR 00906

Participants: Mark McCullough, Architect for McCullough Domínguez Architects; Kevin Griffin; Shaine Grogan

Shaine Grogan: Can you describe what your company does and what your position is?

Mark McCullough: I am a partner in McCullough Domínguez Architects. We are an Architectural Profession Design Service founded in 1997 in San Juan, Puerto Rico. We provide general architectural design services.

Kevin Griffin: What kind of experience do you have with renovating old buildings or renovating historic buildings? What kind of factors should be taken into account?

MM: Well we have some experience in Old San Juan. It matters if you are looking into masonry and concrete. We did an interior project of an old concrete art building. It is important to see if the building is concrete or masonry. (Mark proceeds to showing pictures of the work that was completed and the renovations that kept the general structure of the historic building).

KG: For projects like these is it important to keep the original structure of the building intact?

MM: There are guidelines that you have to follow. Additions are possible, but demolition is not for the most part. For the zoning regulations you have to go the Instuto De Culturo De Puerto Rico. They will have information that explains what you can and can't do to a building.

SG: Okay, thank you. We have had trouble finding zoning regulations. We need to do so to see if alternatives like windmills are possible. We are looking into the use of small windmills.

MM: That should be possible, I'm not completely sure however.

KG: So when you do projects are you used to doing projects with energy alternatives? What kind of products have you used that you like or dislike?

MM: I like how the fluorescent bulbs are coming around. The color of the light is more natural now.

SG: Do you have any experience with energy saving systems?

MM: With Wal-Mart we worked on a project that had skylights. When the sun went down the light level would increase. We have been involved with low-flow toilets.

SG: What about waterless urinells?

MM: Yes we are familiar with them. The secret is to keep the stone changed on a regular basis, because if not it will start smelling. It has to be very well installed and level, and if not it can go bad.

KG: What kind of things can you do to improve an HVAC system for a building that is already functioning?

MM: This is the part to your project that I find odd. You are going to a historic place and trying to figure out how to put an efficient AC system in. The thing about Old San Juan is that there is passive cooling, which means that every building has a patio. This sucks the natural ventilation up through the patio and to the building. Maybe you should look into passive cooling if you have patio space. It is important to use the natural breeze and to keep the sun out of the building.

KG: What is your opinion on renewable energy? What would you say the people of Puerto Rico's view on renewable energy is?

MM: I like it, I think it is a very good thing. The problem with the people is that there is not enough education for the people to understand it.

SG: That is one of our goals for our project, to make a recommendation for the Trust to be a role model. Do you know of any ways to intrigue or educate people on efficiency?

MM: I think making a comparison of energy savings of a specific object would be good. If you look at a house with fluorescent compared to regular lighting and look into the energy savings offered, the construction cost, and the returwn of investment.

SG: Do you have any information of ways to narrow down our recommendations?

MM: You have a building that will be air conditioned, but maybe you could focus on the appliances and making an exhibit and examining ideas for the exhibit because you can't thoroughly examine all the other factors of a building. You would need a professional for each category to analyze all of these options, but if you choose one device or appliance you may be able to make a better analysis.

KG: Okay, well thank you very much for all of the information and your time.

Appendix J: Interview Transcript: Carlos Rodriguez

Date: Wednesday, April 4, 2012, 2:00pm

Participants: Carlos Rodriguez, Electrical Engineer, FEMA; Kevin Griffin; Shaine Grogan

Shaine Grogan: Would you briefly describe what your company does? What is your position at the company and what are some typical responsibilities you have?

Carlos Rodriguez: I work for FEMA right now. When any disasters, hurricanes, etc. take place, the U.S. government will send out FEMA, and that is my department where I work. What I actually do is visit the sites where the damage is located, take an inspection of the area, estimate the damage, and try to understand what is needed in terms of utilities and facilities to get the site back to working. My area of work is what they call a public assistance, which deals with any assistance that is needed by all government and public properties.

SG: So do you work with any energy efficient devices when you do these projects?

CR: Yeah. When a building will be damaged by a disaster, some devices could be destroyed. Many times the device won't have a replacement, or it will be better to replace it with an updated device. We only make recommendations, kind of like you guys are doing. And this will end up with us recommending a newer device, which will often be energy efficient.

Kevin Griffin: Do you ever do work on historic buildings that have been damaged? And do you have to try and preserve the historic character during these jobs?

CR: Actually, the public assistance program works with all government owned buildings, which can range from buildings, roads, bridges, utilities, electrical facilities, etc. So some of the buildings might be historic ones.

SG: Have you ever had to do work to a building in Old San Juan?

CR: I have worked for FEMA for about four years now, and since I've worked here, there has not been much damage in Old San Juan by disasters.

KG: What kinds of energy-efficient devices do you have experience with? Are there any that you like or dislike?

CR: Well in FEMA, what we actually do when we make recommendations, we do it most the time as a medication, so that in the event of another disaster, the same thing doesn't happen. We basically focus on this, and we do not usually try to reduce the energy consumption or anything like that. Based on my experience, though, the solar systems are becoming very popular. Also, the systems that collect the stormwater and use and reuse it for flushing toilets.

KG: So do you have any experience with solar panels and do you see them as viable options for the future of energy conservation in buildings?

CR: The coalition of engineers here performs frequent trainings on this technology, and there are actually a couple of technology universities that teach and certify people for the solar panel installation. It is gaining popularity in the area because of the movement the government has started.

SG: How are the people of Puerto Rico reacting to this movement?

CR: They are responding, but slowly in my opinion. This is because of the initial investment is a lot of money, and they are likely not familiar with the return they will receive. But if you go up to the north and east coasts, you will see some buildings that have the solar panels on the roof.

KG: We will be trying to educate people of Puerto Rico on energy and water conservation. Do you have any suggestions on ways to encourage people into becoming more efficient with their energy and water use?

CR: What we know right now is what the government makes public. They put up announcements on the TV and most of them talk about making savings in your own home. Things like turn off the lights when you leave a room and use high efficiency air conditioners. But for things like solar systems, there is not much publicity. I obviously see a lot of it because it is my area of work. But outside the circle of engineering, there are still a lot of people wondering what is a solar system? So I think it's a good idea to especially target schools and teach them about alternative energies and high efficiency lighting and devices.

SG: Do you have any other suggestions of things we should consider when making our recommendations?

CR: I don't know if you have checked the required permitting for your suggestions. Here in Puerto Rico, the permitting process to perform construction is a little complicated. The idea or concept of a project may sound good sometimes, but there are many times some obstacles with the permitting. Sometimes they may require some sort of environmental analysis, or sometimes an area could be so sensitive that the department of historic preservation does not want a project to happen.

KG: Thank you for meeting with us and the information will definitely help our project.

Appendix K: Interview Transcript: Juan Rodriguez

Date: April 20, 2012

Location: 201 Tetuán Street, 7th floor

We understand that one important part of the Trust's work is to educate the public about conserving the environment and natural resources. Generally speaking, who is the audience for the Trust's education campaigns? How many people do you estimate you reach with your education campaigns per year?

Juan Rodriguez: The audience of the Trust is broad. We do guided tours at the reserves to show the visitors. We have workshops that are focused on ecosystems and are for teachers and community leaders. They then go back to pass the information on to students or the community. We also provide tools to teach, such as books, field guides and so forth. We hold 35-40 workshops per year, educating 300-400 people. Every year, the reserves receive over 65,000 visitors. The goal of the tour is to educate visitors, not for tourism. A major component of the visitors is from schools.

What kinds of educational approaches have you used in trying to educate the public? How effective have they been and how have you measured this? What has been the audience's feedback?

JR: We provide multiple workshops for teachers. Usually the teachers will join more than one workshop. Our education approach is informal but the staff are certified by NAI. We use maps and exhibits to show the teachers and they can perform fieldwork such as collecting data, observations of birds, inventory of plants. The workshops are very hands-on. The content of education was well designed by a professor from Metropolitan University of Puerto Rico. We also have students coming here (Casa Ramón Power) to show them the exhibition room or provide tours in Old San Juan or to Trust's reserves.

Have you ever used any education methods that failed to achieve their educational goals, and if yes, what were they and why were they unsuccessful?

JR: Probably, today's teachers are very technique oriented. We wants to make more information electronically feasible. Currently those resources are not (online), but we are aware of the need. Our next target is to develop distance tools that can be used remotely.

What suggestions do you have that you think would best promote the Trust in being a role model in conserving energy and water in buildings?

JR: For the previous 35 years, the Trust has been focusing on preserving land. In the last 3 years, we added a new goal - to conserve energy and water. We hope to promote a change in the community. But we are not familiar with this subject. People asked us to give a presentation on energy and water conservation, but we couldn't because we didn't know much of it. This (renovation) project will be a new start for us.

Appendix L: Water and Energy Bills

Table 5: Water Bills

	Bi-Monthly Water Consumed in m^3	
	Banco Español	**Casa Ramón Power**
Nov. 2010 **Dec. 2010**	13.5	24.3
Jan. 2011 **Feb. 2011**	23.5	31.5
Mar. 2011 **Apr. 2011**	14.5	102.5
May 2011 **Jun. 2011**	14.5	35.5
Jul. 2011 **Aug. 2011**	12	34.5
Sep. 2011 **Oct. 2011**		44
Monthly Average	7.8	22.7
Adjusted		16.98

Table 6: Energy Bills

	Daily Energy kWh Consumed		Average	Power Factor
	Banco Español	**Casa Ramón Power**	**Temp. °C**	**of CRP**
Dec. 2009	161	550	26	
Jan. 2010	121	465	25	
Feb. 2010	166	515	26	
Mar. 2010	150	532	27	
Apr. 2010	160	510	27	
May 2010	147	503	27	
Jun. 2010	160	583	28	
Jul. 2010	146	536	28	
Aug. 2010	157	558	29	
Sep. 2010	177	567	28	
Oct. 2010	167	550	27	
Nov. 2010	133	528	26	
Dec. 2010	120	511	25	0.848
Jan. 2011	110	499	25	0.848
Feb. 2011	127	529	25	0.850
Mar. 2011	136	521	25	0.847
Apr. 2011	163	503	26	0.847
May 2011	160	515	26	0.843
Jun. 2011	194	489	27	0.856
Jul. 2011	135	463	27	0.844
Aug. 2011		490	28	0.853
Sep. 2011		490	28	0.852
Oct. 2011		482	27	0.850
Nov. 2011		493	26	0.857
Monthly Average	149	513	26.6	0.850

Table 7: Correlation Between Energy Use and Temperature

Banco Español	0.3283
Casa Ramón Power	0.5961