April 2007

Punto Verde Children's Park

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May 1, 2007

Licenciada Angelita Rieckehoff
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Estimada Lcda. Rieckehoff,

Thank you for giving us the opportunity to work with you. We appreciate all of your help in making our experience in Puerto Rico rewarding and memorable. Enclosed is our report entitled Punto Verde Children’s Park. It was written in San Juan, Puerto Rico during the period of March 10 through May 3, 2007. Preliminary work was completed in Worcester, Massachusetts prior to our arrival in Puerto Rico. Copies of this report are simultaneously being submitted to Professors Gerstenfeld, Vernon-Gerstenfeld, and Mrs. Arsuaga for evaluation. Upon faculty review, the original copy of this report will be catalogued in the Gordon Library at Worcester Polytechnic Institute. We appreciate the time that you have devoted to us.

Sincerely,

Martin Maccaferri
Oliver J. Salmon
Mikayla Thompson
Nicholas Wilbur
Report Submitted to:

Professor Susan Vernon-Gerstenfeld  
Professor Arthur Gerstenfeld  
Mrs. Beatriz Arsuaga  

Puerto Rico, Project Center

By

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Punto Verde

PUNTO VERDE CHILDREN’S PARK

May 1st 2007

This project report is submitted in partial fulfillment of the degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do not necessarily reflect the positions or opinions of Punto Verde or Worcester Polytechnic Institute.

This report is the product of an education program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.
EXECUTIVE SUMMARY

Humans have had many negative effects on the environment. The causes include the over use of non-renewable energy and the buildup of solid waste. Over the last half century, the consumption of natural resources, such as fossil fuels, has grown four fold (American Association for the Advancement of Science [AAAS], 2006). The burning of fossil fuels emits pollutants into the air, which have adverse effects on the atmosphere. Renewable energy technology can ease environmental problems caused by non-renewable energy use.

The sun is an example of an extremely abundant renewable energy source. In a single day, the sun can deliver enough light and heat energy to power a home for over a year (U.S. Department of Energy [DOE], 2007). Harnessing this energy is an opportunity for humans to save the environment and to continue comfortable and familiar lifestyles. Puerto Rico, being located near the equator, is subject to an abundance of sunshine year-round and is therefore a perfect location to take advantage of solar power. The technology will actively provide power 365 days a year.

Biodiesel is another example of a renewable energy source. Biodiesel is a fuel used as an additive or replacement to diesel fuel. It is made from used vegetable oils, but is sometimes created from used cooking oils or animal fat (Union of Concerned Scientists, 2005). Technologies have also been developed to make biodiesel fuel from algae (Sheehan, Dunahay, Benemann, & Roessler, 1998). Biodiesel, which can be used in place of petroleum and oil, can lower non-renewable energy usage.

Besides using renewable energy sources, energy can be conserved by using cool roofing, insulation, and green construction. San Juan, Puerto Rico is a hot and humid
area that would benefit from insulation such as green roofing. Green roofing significantly decreases the ground level ozone production, by decreasing the roof temperature (Scholz-Barth, 2001). Green roofing also addresses environmental issues such as high rainwater runoff (Green Roofs for Healthy Cities, 2005; Greenroofing.com, 2007; Scholz-Barth, 2001).

In addition to non-renewable energy, solid waste is an economic and environmental problem. According to the EPA (2006e), there are huge amounts of solid waste being produced in Puerto Rico every year, but only small amounts of this waste are being recycled. According to the Caribbean Recycling Foundation, at 1,971 lbs of solid waste per capita per year, Puerto Rico generates more waste per person than mainland United States (Caribbean Recycling Foundation, 2004; EPA, 2007c). Furthermore, 75 percent of that solid waste is recyclable, but only 20 percent is reused (PRMA, 2007).

One effect of solid waste build up is the creation of landfills. According to the CIA (2007), in 2006, the population of Puerto Rico was nearly four million people. The EPA (2006b) believes that the Island’s thirty-two landfills will soon fill up. This is because of Puerto Rico’s large population and the overproduction of solid waste. The Solid Waste Management Authority has recognized that one way to reduce the landfill buildup is recycling.

Based on the increasing build up of solid waste, studies have shown that the current recycling program in Puerto Rico has been ineffective. Puerto Rico has attempted to rectify the Island’s waste problem by using education in schools and public meeting areas (Courtney, Dasso, Holland & Mier, 2004). Courtney et al. (2004) agree that these programs have been ineffective and almost non-existent. Despite the efforts to develop
recycling programs in Puerto Rico, the Island has not found an effective way to educate its population about recycling. In San Juan, the Punto Verde organization is investigating informal recycling education for a children’s theme park that it is constructing.

Punto Verde is an organization whose primary goal is to improve the economy of San Juan, Puerto Rico by catalyzing the growth of small businesses (Aull, 2002). This organization is currently in the process of developing the Punto Verde Park, located in the northernmost part of the Luis Muñoz Marín Park, which is located in metropolitan San Juan. The main objective of the Punto Verde Park is to create small business ventures for low income citizens of San Juan. The Park will be an eco-friendly, interactive children’s park. Punto Verde has allotted money to promote local businesses, while educating the youth about the benefits of eco-friendly concepts, including recycling.

The goal of our project was to develop plans for waste management and propose green technology to address energy concerns in the Punto Verde Park. The objectives were to develop a system for the Park’s solid waste management, propose methods for energy conservation, and investigate renewable energy sources for the Park.

Our project group determined ways in which recycling and composting could be used within the Park to decrease the amount of waste being sent to landfills. In order to do so, we interviewed experts in the waste management field to determine how much waste will be produced in the Park on a weekly basis. We then used this information to determine how much of the waste can be composted, how much can be recycled, and how much would need to be sent to landfills. We estimated that 40 percent of the Park’s waste will be compostable, 20 percent recyclable, and 40 percent landfill waste.
We interviewed the recycling company Grupo Comunitario de Reciclaje in order to set up a recycling program for the Park. The company will train employees of the Park to sort recyclable materials. They will also provide bins and signs around the Park to encourage park patrons to recycle. These aspects of the program will promote recycling within the Park as well as ensure that park patrons understand how recycling can benefit the environment. Lastly, the company will manage all of the Park’s recyclable materials. They will transport and reimburse the Park for aluminum, glass, plastic, and paper.

We also researched ways in which composting could be incorporated into the Park. Based on the amount of waste that will be produced in the Park on a weekly basis, we determined that an in-vessel composter would be the best choice for the Park. In-vessel composters are able to process large amounts of waste as well as block odors and unwanted animals. However, we determined that an in-vessel composter does not fit within Punto Verde’s budget. Therefore, we recommend Punto Verde investigate ways in which the composter can be donated. As a non-profit organization, the advantages of the composter will come from educating the community about the benefits of composting as well as from decreasing the amount of waste that will need to be sent to landfills.

We also recommend that the Park use small scale composting as an educational tool. We recommend that the Park has a small backyard composter that demonstrates the composting process as well as have signs that teach park patrons how the composting process works. Such a display will allow park patrons to see how composting can be used in their own backyards. The composter also gives opportunity for small business development in which workers can operate the composter and sell the compost.
We also investigated the feasibility of incorporating a green roof on the main office building of the Park. The green roof could potentially cool the building so that less electricity would be used on air conditioning. By interviewing Punto Verde’s landscape architect, we discovered that the building could not support the weight of a green roof. However, we recommend that green roofing be used as a display that educates park patrons on the benefits of green roofing and the positive impact that it will have on the environment.

Lastly, our project group investigated ways in which renewable energy sources could be incorporated into the Park. We researched vendors for solar power and determined how the use of solar power could reduce the Park’s energy consumption. Using net present value, we determined when the initial investment of the solar technology would be paid off. Through that analysis, we determined that solar power is a reasonable investment for addressing the Park’s energy concerns.

Current policy in Puerto Rico does not approve of local power generation sources, such as solar energy, to be used in the same electrical system as energy that is provided by the Autoridad de Energía Electrica. However, this legislation is currently being amended. We recommend that Punto Verde use solar power when legislation concerning net metering practices is passed. If Punto Verde takes advantage of this technology, we recommend that park patrons are shown how the technology works and benefits the environment. We believe that if this technology is made to be an additional educational attraction, in conjunction with the permitting of net metering on the Island, it will have the potential to inspire others to turn to this practical and clean energy source.
Our project group also researched ways in which biodiesel could be used to produce electricity for the Park. Using net present value, we determined that installing a diesel generator in the Park and fueling it with biodiesel is the Park’s most cost-effective option for power generation. Because biodiesel is an environmentally friendly alternative to fossil fuels, we believe that the use of this technology would still be within the eco-sensitive mission of the Punto Verde Park. Encouraging its use throughout the Island would improve environmental concerns worldwide.

However, we recommend that the Punto Verde administrators do not immediately invest in a biodiesel generator for the Park. Information regarding consistency of the fuel supply, market price, estimated market price inflation, and fuel quality is not currently available. This information is crucial for the feasibility of a biodiesel power generation plan.

Our project group believes that all aspects that we investigated in this project will be beneficial from an educational outlook. By incorporating these concepts, even on a small scale, park patrons will be educated about subjects which they previously had no knowledge. With over 300,000 visitors per year, the Park will provide vast exposure to eco-friendly practices. This Park will take the step to increase the knowledge of problems that adversely affect the environment and how these problems can be addressed. Ideally, the spread of knowledge will eventually lead to change.
ABSTRACT

This report, prepared for Punto Verde of Puerto Rico, proposes a waste management plan for the Punto Verde Park. The plan includes composting, recycling, and waste removal. The report also explores the feasibility of incorporating green roofing, solar power, and biodiesel technology within the Park. We found that green roofing is not feasible at this time, but recommend creating an educational display of a green roof. We also found that a photovoltaic solar system will benefit the Park. Lastly, we determined that although biodiesel is the Park’s most cost effective energy option, there is not currently enough information available to commit to the technology.
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Martin Maccaferri, Oliver Salmon, Mikayla Thompson, Nicholas Wilbur

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Energy conservation: Oliver Salmon

Effects of solid waste: Martin Maccaferri, Oliver Salmon, Mikayla Thompson, Nicholas Wilbur

Waste management in Puerto Rico: Martin Maccaferri, Oliver Salmon, Mikayla Thompson, Nicholas Wilbur

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Appendix E – Soda Bottle Toy Designs: Oliver Salmon
Appendix F – Estimation of Park Visitors: Mikayla Thompson
ACKNOWLEDGEMENTS

We would like to thank the following people for their contributions to this project. Their help was greatly appreciated.

Beatriz Arsuaga
Vilma Blanco
Angélica Casanova
Arthur Gerstenfeld
Matilde Licha
Javier Naveira
Carolina Nevares
Bernice Pagán
Evelio Pina
Angelita Rieckehoff
Carol Rivera
Ramón Sierra
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CHAPTER 1: INTRODUCTION

Humans have had many negative effects on the environment. The causes include the over use of non-renewable energy and the buildup of solid waste. Over the last half century, the consumption of natural resources, such as fossil fuels, has grown four fold (American Association for the Advancement of Science [AAAS], 2006). The burning of fossil fuels emits pollutants into the air, which have adverse effects on the atmosphere. The adverse effects include poor air quality, contaminated rainwater, and global warming (U.S. Environmental Protection Agency [EPA], 2006c; Mihelich & Williams, 2007).

Global warming is an increase in the temperature of the Earth. Some studies have argued that global warming is beneficial to human health (Moore, 1996). However, more studies indicate that global warming increases potential health problems (Australian Greenhouse Office, 2004; Reinberg, 2007). Studies also indicate that global warming has a correlation with extreme weather, adversely affects the economy, and changes ecosystems worldwide (Preston, 2005).

Experts recommend that carbon emissions from fossil fuels need to be reduced by 60 percent to avoid future catastrophic climate change (“Renewable energy”, 2005). If the high use of fossil fuels continues, then the Earth’s temperature will continue to increase (EPA, 2006d). Other studies have argued that there is not enough evidence to know that current global warming exceeds natural weather patterns (Exxon Mobil, 2006). This argument is reasonable since global warming trends are accurately measured over the course of centuries (Mann, 1998), while natural climate cycles, such as the Ice Age Cycle, are estimated to occur over the course of 100,000 years (Shackleton, 2000). As a result, it is inconclusive whether current global temperature trends are unnatural.
Regardless of the relationship to natural patterns, global warming needs to be addressed and could be slowed by reducing the use of non-renewable energy (EPA, 2006d).

The depletion of the Earth’s natural resources is an issue that needs to be addressed. From 2003 to 2004, renewable energy consumption increased less than 1 percent, while the rate of energy consumption increased by over 2 percent (“Renewable energy,” 2006). The world is dependent on non-renewable energy. As of 2004, the non-renewable energy resources consisting of petroleum, natural gas, coal, and nuclear power have accounted for nearly 93 percent of the world’s energy consumption (Energy Information Agency, 2006).

Some less harmful alternative forms of energy include solar energy, wind power, ethanol, and biodiesel (Feltus, 2006). These energy sources create less waste while causing less harm to the environment (Feltus, 2006). However, these renewable energy supplies come at a higher initial cost than non-renewable energy sources (Golob, & Brus, 1993; U.S. Department of Energy, Energy Information Administration [EIA], 2005).

Recent technologies, such as some hybrid cars, help to address pollutant emissions (Fukuo, Fujimura, Saito, Tsunoda & Takiguchi, 2001; Smokers, Gense, Rijkeboer & Dijkhuizen, 2004) and also improve energy efficiency (Demirdoven & Deutch, 2004; Fukuo et al., 2001). Despite these benefits, hybrid cars are estimated to be less than 1 percent of cars on the market (Zubrin, 2006). Finding ways to increase the use of renewable energies is necessary for maintaining a stable environment.

Energy efficient systems such as green roofing, cool roofing, and energy star-rated appliances can also greatly reduce energy consumption. Green roofing is a way to incorporate plant-life into the roofing. Cool roofing involves designing roofing to reflect
light and emit heat back into the sky (Cool Roof Rating Council, 2007). Energy star-rated appliances are those appliances that have low enough energy consumption to meet the criteria of the energy star program.

Green roofing is an example of a way to make a building a more energy efficient system and may eventually become a money saving technique (EPA, 2007b). Despite its potential, green roofing has yet to be put into widespread use.

The need for renewable energy and a decrease in current energy usage are concerns in communities around the world. Puerto Rico is an example of one of these communities. The Island has a high need for the reduction of oil usage. According to McPhaul (2004), the Puerto Rico Electric Power Authority [PREPA] made a goal to reduce its dependence on oil from 71 to 47 percent by the year 2012 by using wind and hydro power whenever possible. The University of Puerto Rico Mayaguez has explored ways to reduce energy usage on the Island as well. Researchers investigated lining buildings with solar panels in order to keep buildings cool without air conditioning (McPhaul, 2004). Information about the technology of solar panels can be found in Chapter 2.

Utilizing more renewable energy and decreasing energy usage are not the only environmental and health concerns around the world. According to the EPA (2006b), solid waste buildup is harmful to the environment and human health. Recycling programs reduce solid waste, which makes for a cleaner environment (EPA, 2006b). Fava, de Haes, Sonnemann, Dubreuil, & Gloria (2006) claim that the use of recyclable materials is vital to sustaining the Earth.
In local communities around the world, recycling programs can be implemented to improve the environment. In Puerto Rico, the Solid Waste Management Authority (SWMA) has attempted to create programs that will promote recycling (EPA, 2006a). Despite these attempts, the management and disposal of solid waste remains a concern in Puerto Rico (EPA, 2006e). Seventy-five percent of Puerto Rican solid waste is recyclable and only 20 percent is reused (Puerto Rico Manufacturers Association [PRMA], 2007). As of 2004, Puerto Ricans produced 5.4 pounds of solid waste per person per day, whereas the U.S. produced 4.5 pounds of waste per person per day (Caribbean Recycling Foundation, 2004; EPA, 2007c). As a result, more waste per person is generated in Puerto Rico than in mainland United States. According to the EPA (2006e), the lack of recycling in Puerto Rico is a major problem that has made a negative impact on the environment.

In 1992, the Solid Waste Reduction and Recycling Act was passed by the Commonwealth of Puerto Rico, with a goal of reducing solid waste by 35 percent through recycling (PRMA, 2007). Many amendments have been added to the act since 1992, but the goal has not been met (PRMA, 2007).

In addition to unsatisfactory recycling programs, Puerto Rico has large buildups of waste. According to the EPA (2006e), most of Puerto Rico’s solid waste is dumped into the Island’s thirty-two landfills, which are quickly filling up. Furthermore, in 2006, the EPA ordered that the Toa Baja, Aguadilla, and Santa Isabel landfills in Puerto Rico be shut down; they did not comply with the federal landfill laws. Seepage of waste into ground water was a public health hazard in these landfills (“EPA closes,” 2006). With the overfilling of landfills and the health hazard that they cause, an alternative to the
waste disposal and an improvement to the recycling programs is a concern that needs to be addressed now.

Some of the more widespread reasons people recycle are for the well being of others or the environment and in response to economic or legal incentives (Lund, 2004). Lund (2004) asserts that in communities with successful recycling programs, the citizens need motivation to recycle. Several communities in California are examples of where motivated citizens have had successful recycling programs (California Integrated Waste Management Board [CIWMB], 2007).

One common way to promote recycling is to educate children (CIWMB, 2007). One concern in Puerto Rico is the recycling education program. A recent report evaluating recycling education in schools on the Island found that not all schools had a program (Courtney, 2004). The researchers also concluded that the few examples of Puerto Rican educational recycling programs in schools were not effective (Courtney, 2004). One new way to educate Puerto Rican children on recycling is through informal education facilities. In San Juan, the company Punto Verde is investigating informal recycling education for a children’s theme park that it is constructing.

Punto Verde is an organization whose primary goal is to improve the economy of San Juan, Puerto Rico by catalyzing the growth of small businesses (Aull, 2002). The organization also strives to promote green lifestyle and technology on the Island. Punto Verde is currently in the process of developing the Punto Verde Park, located in San Juan, in the northernmost part of the Luis Muñoz Marín Park. The main objective of the Park is to create small business ventures for low income citizens of San Juan. The Park will be an eco-friendly, interactive children’s park. Punto Verde has allotted money to
promote local businesses, while educating the youth about the benefits of eco-friendly concepts, including recycling.

The goal of our project is to develop plans for waste management and propose green technology to address energy concerns in the Punto Verde Park. The objectives are to develop a system for the Park’s solid waste management, propose methods for energy conservation, and investigate renewable energy sources for the Park.
CHAPTER 2: BACKGROUND

In order for the reader to understand the goal and objectives, this background chapter contains information on the need for renewable energy, renewable energy technologies applicable to Puerto Rico, energy conserving technologies, the effects of solid waste on Puerto Rico and the world, current waste management in Puerto Rico, and arguments for and against composting.

THE NEED FOR RENEWABLE ENERGY

The world is dependent on non-renewable energy. As of 2004, the non-renewable energy resources consisting of petroleum, natural gas, coal, and nuclear power accounted for nearly 93 percent of the world’s energy consumption (Energy Information Agency [EIA], 2006). Puerto Rico is dependent on non-renewable energy as well. The Puerto Rico Electric Power Authority, the only electric power company in Puerto Rico, uses oil for 98 percent of its energy output (Autoridad de Energia Electrica, 2002).

The price of non-renewable energy sources varies overtime and often reaches high points. The price of oil has varied extensively since the 1970’s, even when the prices are inflation adjusted (McMahon, 2007). As shown in Figure 1, the current price of oil could be argued to be in an upward or a downward trend, with or without inflation adjustments (McMahon, 2007). Therefore, it is a risky investment to be highly dependent on oil.
The cost of electricity has been increasing with time (Winebrake, 2004). Fossil fuels generate a significant amount of electric power. Therefore, the EIA (2005) claims that the increasing need of electric power and the decreasing supply of fossil fuels that generate the power will make fossil fuels an expensive, continuous investment.

In addition to cost, many non-renewable energy sources are argued to be environmentally hazardous (Mihelich & Williams, 2007). Fossil fuels add to global warming by creating carbon dioxide and methane, which trap heat near the Earth’s surface (Mihelich & Williams, 2007). This heat near the Earth’s surface is known as the greenhouse effect. Although some greenhouse effect is natural, burning fossil fuels brings the effect to unnaturally high levels and raises the Earth’s temperature (Mihelich
According to Mihelich and Williams (2007), the use of these non-renewable energy sources has been said to add to global warming. Others have argued that there is not enough evidence to conclude current global warming exceeds natural patterns (Exxon Mobil, 2006). Regardless of the relationship to natural patterns, the EPA (2006) has argued that global warming can be slowed by reducing the use of non-renewable energy (EPA, 2006). Renewable energy technology can ease the economic and environmental problems caused by non-renewable use.

The sun is an example of an extremely abundant renewable energy source. In a single day, the sun can deliver enough light and heat energy to power a home for over a year (U.S. Department of Energy [DOE], 2007). Harnessing this energy is an opportunity for humans to save the environment and to continue comfortable and familiar lifestyles. There are many methods of collecting solar energy. Many technologies utilize the energy of the sun and put it to direct use or convert it into other forms of energy. A solar updraft tower is a wide greenhouse, connected to a large tower. The tower utilizes the movement of hot air up the tower from the greenhouse to spin turbines (Schlaich, Bergermann, Schiel & Weinrebe, 2005). Various solar cooking units also exist, which direct the heat from sunlight into a small area for cooking food (Global Sun Ovens®, 2007; Solar Cookers International, 2005; Sport Solar Oven, 2006).

Currently, one of the most popular methods of solar energy production is through photovoltaic cells (PoweredGenerators.com, 2002). This growing technology has the ability to convert sunlight directly into electricity using chemical properties within each of the solar cells. Solar cells have been used in the past in conjunction with space exploration and small, portable, electronic devices. The popularity of solar power is
growing as it is used more frequently for residential and industrial needs (PoweredGenerators.com, 2002).

Puerto Rico, being located near the equator, is subject to an abundance of sunshine year-round and is therefore a perfect location to take advantage of photovoltaic technology. The technology will actively provide power 365 days a year with no power losses due to an absence of sunshine. The U.S. Department of Energy implemented the Solar Energy Program for Puerto Rico in 2005. The program was designed to promote solar power as a renewable energy source and provide assistance to those who want to set up a solar photovoltaic system (DOE, 2007b).

Biodiesel is another example of a renewable energy source. Biodiesel is a fuel used as an additive or replacement to diesel fuel. It is made from used vegetable oils, but is sometimes created from used cooking oils or animal fat (Union of Concerned Scientists, 2005). Technologies have also been developed to make biodiesel fuel from algae (Sheehan, Dunahay, Benemann, & Roessler, 1998). Biodiesel, which can be used in place of petroleum oil, can lower non-renewable energy usage.

Biodiesel can be used in some diesel engines, although sometimes the engines need to be modified for reasons such as cold weather (Addison, 2006). With the right design, an engine can run on treated, used vegetable oil, or unmodified, new vegetable oil (Addison, 2006). An increase in diesel engine vehicles and biodiesel production could potentially replace the petroleum fuel dependency in the car market.

Biodiesel can address other oil concerns as well. As mentioned earlier, oil is a key contributor to electricity in places like Puerto Rico. However, biodiesel can be used to generate electricity. Biodiesel powered electric generators already exist (JS Power
Limited, 2004). In addition, some diesel generators are capable of utilizing biodiesel fuel (JS Power Limited, 2004). If biodiesel generators were built on a larger scale, they could replace the petroleum-based generators in power plants.

There are some disadvantages to biodiesel as well. Both biodiesel and diesel emit harmful pollutants when they are combusted. Nitrogen oxide emissions are higher from burning biodiesel than diesel (EPA, 2002). As a result of the nitrogen oxides, burning biodiesel fuel may result in more ozone production (EPA, 2002). Therefore, biodiesel fuel is predicted to make more smog than diesel fuel (Union of Concerned Scientists, 2005). However, using biodiesel instead of diesel fuel lowers the overall carbon dioxide, hydrocarbon, particle mass, carbon monoxide, and total toxic emissions (EPA, 2002).

**ENERGY CONSERVATION**

Besides using renewable energy sources, energy can be conserved by using cool roofing, insulation, more efficient appliances, and green construction. Cool roofing is a method used to lower the temperature in the building that it covers, as well as the urban heat island effect of the area surrounded by it. The urban heat island effect is an increase in the average temperature of an urban area due to a high percent of concrete and dark coloring on roofing exposed to the sun (Green Roofs for Healthy Cities, 2005). Cool roofing is a roof that reflects more light than traditional roofing. This is achieved by using a reflective material, such as metal or cement, or a reflective coating, such as white paint, to coat or construct the roof (EPA, 2007).

Insulation is a material that prevents the transfer of heat, electricity, or sound (Merriam-Webster Online, 2007). It can be used on buildings to lower the use of cooling
and heating units, while achieving the same interior temperature. Insulation can therefore save energy and money. San Juan, Puerto Rico is a hot and humid area. In hot and humid areas, there are both passive and active approaches to maintaining a comfortable interior climate (Heerwagen, 2003). Passive approaches include ventilation, shading, a lightweight building design, so as to permit rapid transfer of heat, and waterproofing of the building (Heerwagen, 2003). Green roofing addresses both active and passive design concerns.

**Green Roof Insulators**

Green roofing involves incorporating plants on top of a roof in order to slow the transfer of heat into or out of the building (Green Roofs for Healthy Cities, 2005). Green roofs that have a low soil density, a high moisture content, and plants with large leaves work as the best insulators (Green Roofs for Healthy Cities, 2005). There are many advantages to green roofing, one being economic. In an extreme example, the Possman Cider Cooling and Storage Facility, Frankfurt, Germany, had a two to three year payoff of their green roofing due to lower cooling and heating costs saving them money directly and reducing the need to buy more infrastructure for temperature regulation (Green Roofs for Healthy Cities, 2005).

The vegetation in green roofing addresses environmental issues as well. Green roofing both slows and lowers the rainwater runoff (Green Roofs for Healthy Cities, 2005; Greenroofing.com, 2007; Scholz-Barth, 2001). About 25 percent of rainwater becomes runoff from green roofing, as opposed to the normal 75 percent in metropolitan areas (Scholz-Barth, 2001). In addition, the soil acts as a filter to treat the water before it
becomes runoff, as opposed to the normal metropolitan drainage system, which may or may not have water treatment before entering a local water source (Scholz-Barth, 2001).

Green roofing can also address poor air quality in cities. Ground level ozone is the main component of smog (Scholz-Barth, 2001). Green roofing significantly decreases the ground level ozone production, by decreasing the roof temperature (Scholz-Barth, 2001).

There are also undesirable aspects to green roofing. Green roofing can weigh from 15 to 150 pounds per square foot (Scholz-Barth, 2001). Depending on the specific building design and the weight of the proposed green roofing, the normal roofing may require additional structural support before green roofing can be added.

Initial cost of green roofing can be high as well. Green roofing can cost as little as four dollars per square foot to over forty dollars per square foot (Greenroofing.com, 2007). This makes green roofing an expensive proposition since it comes in addition to the price of the support roof, which can often serve as a roof in and of itself.

Depending on the design, green roofing may require regular maintenance as well. This regular maintenance will require both time and money. Mistakes in the building design or in the green roofing design could also result in severe structural problems, such as cracking or molding. See Appendix B for information on green roofing technologies.

**EFFECTS OF SOLID WASTE**

In addition to non-renewable energy, solid waste is an economic and environmental problem. According to the EPA (2006e), there are huge amounts of solid waste being produced in Puerto Rico every year, but only small amounts of this waste are
being recycled. According to the Caribbean Recycling Foundation, at 1,971 pounds of solid waste per capita per year, Puerto Rico generates more waste per person than mainland United States (Caribbean Recycling Foundation, 2004; EPA, 2007c). Furthermore, 75 percent of that solid waste is recyclable but only 20 percent is reused (PRMA, 2007).

One effect of solid waste build up is the creation of landfills. According to the CIA (2007), in 2006, the population of Puerto Rico was nearly four million people. The EPA (2006b) believes that the Island’s thirty-two landfills will soon fill up. This is because of Puerto Rico’s large population and the overproduction of solid waste. The SWMA introduced alternatives to landfill disposal in 1993, including the rehabilitation of the current landfills and the introduction of waste to energy facilities. These alternatives, however, are very expensive, costing the government of Puerto Rico millions of dollars annually (Schell, 1992). The SWMA has recognized that one way to reduce the landfill buildup is recycling.

WASTE MANAGEMENT IN PUERTO RICO

The EPA (2006d) has recognized that the currently overpopulated world has an urgent need for the utilization of recycling. In 2006, the average person produced about 4.3 pounds of solid waste per day (Maiorano, McGillvray, Nakamura, 2006). According to the EPA (2006c), the amounts of materials that are wasted in the world are rapidly increasing. The EPA claims that recycling, where it is currently used, has significantly reduced the amount of solid waste produced. See Appendix C for recycling and other waste management technologies.
Based on the increasing buildup of solid waste, studies have shown that the current recycling program in Puerto Rico has been ineffective (Courtney, Dasso, Holland & Mier, 2004). Although 75 percent of this solid waste is composed of recyclable material, only 20 percent of this solid waste is recycled (PRMA, 2007). The Commonwealth of Puerto Rico has identified this issue and has implemented a program to address the lack of recycling. In 1992, the Commonwealth of Puerto Rico passed the Solid Waste Reduction and Recycling Act. The goal of this act was for the Puerto Rico Solid Waste Authority to develop and implement a comprehensive program to reduce the amount of solid waste produced by 35 percent (PRMA, 2007). Many amendments have been added to the act since 1992, but the goal has not been met (PRMA, 2007). The recycling rate is currently 20 percent (PRMA, 2007).

Puerto Rico has attempted to rectify the Island’s waste problem by using education in schools and public meeting areas (Courtney, Dasso, Holland & Mier, 2004). Courtney et al. (2004) agree that these programs have been ineffective and almost non-existent. Despite the efforts to develop recycling programs in Puerto Rico, the Island has not found an effective way to educate its population about recycling. The recycling rate in Puerto Rico has only increased approximately 10 percent since 1992 (PMRA, 2007). Punto Verde aims to fill in this gap with an interactive park that educates the children of Puerto Rico about recycling. Educational parks, such the Punto Verde Park, zoos, and museums are venues for informal education.
Informal Education

Informal education includes the use of hands-on, interactive attractions, such as exhibits used in museums to educate children (Screven, 1996). Children from the ages of three to twelve years old are the main targets for the attractions in the Punto Verde Park. The focus of these attractions is to entertain and educate the children while they play.

According to Screven (1996), informal education can be used to educate children on cultural and social issues. Furthermore, the author believes that natural encounters are necessary for the learning process, many times enhancing what is already known. Paris (2002) also believes that learning with objects is necessary for education. He extends this idea and claims that the use of informal education increases retention of the learned material. The National Science Teacher’s Association [NSTA] (2007) agrees with Paris in that informal education is important for learning.

Screven (1996) suggests that in order for an attraction to be educational, it must be goal oriented and include discovery activities. Children should be able to solve tasks that lead to a rewarding response. Pressing buttons and the use of lights and sounds can be satisfactory for children as a reward for solving the task at hand. At the same time, these simple, interactive activities can sustain a child’s interest in the attraction, while enhancing their education. Paris (2002) attributes the enhanced learning that these simple activities provide to the fact that children are able to decide what and when they want to learn. Paris agrees with Screven that the use of interactive activities motivates children, leading to a better learning experience. The NSTA (2007) goes even further to say that informal education brings multiple perspectives to teaching and learning. According to
the NSTA (2007), educators gain insights on how to better teach science, and students find new approaches to learning.

In the past, many organizations have used parks and other interactive activities to educate children about recycling in a fun environment. Disney World, located in Florida, has created a mascot character named ‘Recycle Rex,’ who is a dinosaur that interacts with the children and encourages them to recycle (Schaffer, 1994). In the United States, the hit show Bob the Builder is used to promote recycling. In the cartoon, Bob the Builder uses recycled materials and renewable energy, such as solar power, to build a new town (‘Yes we can,” 2006). Studies have shown that the show is successful at educating children (‘Yes we can,” 2006). Mascots and television shows are successful ways to influence young minds about recycling.

**COMPOSTING**

Another way to address the overfilling of landfills in Puerto Rico is to find alternatives, other than recycling, to the disposal of solid waste. One of these alternatives is composting. Composting is the conversion of organic matter into an enriched soil-like substance that can be used as fertilizer (Merriam-Webster Online, 2007b). According to the Solid Waste Composting Council, up to 40 percent of all solid waste generated in the U.S. can be composted (Michaels, 1994). Studies show that an overwhelming amount of organic waste is dumped into landfills. Furthermore, this organic waste will not decompose due to the fact that there is no oxygen present at the core of the landfill. The Garbage Project, a study of Arizona’s consumption of waste, found that landfills in Arizona contained a 40 year old sample that was still made of 47 percent organic
material. This shows that much of the waste in this landfill could have been reduced if the organic material was originally composted.

Composting not only has the advantage of decreasing waste, but has an economic advantage as well. Disposal of solid waste into landfills can be expensive. As of 1994, the city of New York paid $95 per ton to dispose of solid waste into landfills. Annually, the city’s landfill waste consists of over 120,000 tons of yard waste and 75,000 tons of kitchen waste, both of which can be composted (Michaels, 1994). Composting reduces the amount of waste put into landfills, which means that a large amount of money spent on waste disposal can be saved if composting is used. Composting can save money on a small scale as well. Composting produces fertilized soil that homeowners can substitute for purchase fertilizers (Hansen, 1993).

Some studies suggest that there are disadvantages to composting. Some disadvantages are that the final product may contain contaminants, runoff from the compost can affect ground water, odors may be produced, and the production of methane may be harmful to the air (Couling, 1990). Other studies show that this production of methane can be beneficial when used as a form of renewable energy in place of fossil fuels. The methane can be used for cooking, heating, cooling, lighting, and generating electricity (Appropriate Technology Transfer for Rural Areas, 2002). See Appendix D for information regarding the composting process.
CHAPTER 3: METHODOLOGY

The goal of our project was to develop plans for waste management and propose green technology to address energy concerns in the Punto Verde Park. The objectives were to develop a system for the Park’s solid waste management, to propose methods for energy conservation, and to investigate renewable energy sources for the Park. In order to do so, we developed a methodology to address these objectives. We followed the following steps:

- Estimate how much waste the Park will produce on a daily basis
- Investigate the best procedure for the Park’s waste removal
- Investigate ways in which recycling and composting can reduce the amount of waste that the Park will send to landfills
- Research ways in which green roofing, solar power, and biodiesel can be effectively incorporated into the Park’s design
- Create cost analyses for solar power, composting, and biodiesel

ESTIMATE WASTE PRODUCTION

In order to estimate the Park’s waste production, we obtained an estimate from Punto Verde directors, of how many people will visit the Park per day. See Appendix F for information concerning the estimated amount of park visitors. In order to determine how much waste each person will produce per day, we interviewed Henry Flores from the Consolidated Waste Services Corporation. We used information from Henry Flores because we did not receive reliable information from other companies. From this data, we calculated how much waste the Park will produce per day. With the help of Flores,
we determined what size dumpsters are necessary to manage the Park’s daily waste as well as what services would be necessary for exporting the waste. Flores also helped us determine how much of the Park’s solid waste would be recyclable.

**INVESTIGATE COMPOSTING AND RECYCLING**

In order to implement an effective recycling program within the Punto Verde Park, we asked directors of Punto Verde how much and what types of waste they wanted to recycle and compost. Once we obtained this information, we researched ways in which the director’s desires for recycling and composting could be met. First, we determined how much space within the Park was allotted to composting and recycling. Next, we interviewed Mariny Vázquez from Grupo Comunitario de Reciclaje to collaborate with their company in setting up a recycling program for the Park. We chose that company because, like Punto Verde, they are a worker owned corporation with an interest in small business development. They also have a pre-existing relationship with Punto Verde. Together with Grupo Comunitario de Reciclaje, we developed a proposal for the Park’s recycling program. We gave Vázquez a map of the Park and descriptions of all of the attractions. She used our information to determine areas of the Park where recycling centers would be feasible. We also discussed ways in which the recycled materials would be sorted and transported to the recycling plant.

We researched different composting systems to determine what type of system would meet the needs of the Punto Verde Park. We then researched vendors online for composting systems, noting the size, cost, and capacity of each unit. We contacted these
vendors by email to determine how their composting units could specifically cater to the Park.

We also investigated small scale backyard composting as an educational tool. We researched vendors online for composting bins and compared the prices given by the vendors. Lastly, we determined ways in which signs could be used to educate children on the composting process. We designed signs that will teach children about the composting process with pictures instead of words.

INVESTIGATE GREEN ROOFING

Our project group researched the methods, techniques, and costs of establishing a green roof for the office building in Punto Verde’s eco-park. In order to obtain information on the design and installation process of green roofing, we conducted an informal telephone interview with Steve Skinner and Rick Clark from American Hydrotech Incorporated, a green roofing vendor. Skinner and Clark provided us with information on the process for properly designing a green roof. They also provided us with tables that assisted us in estimating green roof weights and heights. Having obtained that information, we discussed our data with the structural and landscape architects of the Punto Verde Park to determine if the green roof was feasible.

INVESTIGATE SOLAR POWER

Our project group analyzed the feasibility of using solar power in the Punto Verde Park. First, we conducted research on modern methods for utilizing solar energy. We decided to focus our analysis on photovoltaic cells. We also researched the different
techniques that are used to obtain and store electrical power from photovoltaic cells in order to develop the best possible system for Punto Verde’s use.

We conducted informal phone interviews with solar power vendors and installers: Casa Solar, Global Energy, Innergy Power, and Pacific Solar Tech. With data that we gathered from these companies, we determined the cost of a solar system for the Punto Verde Park, the availability of the equipment, and how to apply their products correctly for our use. We also researched the regulations and incentives that are available on the Island regarding the use of renewable energy. We combined all of this information and conducted a cost analysis to determine when the Park’s energy savings will compensate for the Park’s initial investment.

**INVESTIGATE BIODIESEL**

Our project group investigated the possibilities of using biodiesel fuels to generate power for the Punto Verde Park. We interviewed Javier Naveira, a representative from Punto Verde who is currently in the process of starting a biodiesel company, Biofuels of Puerto Rico, to determine the electrical needs of the Park. We also investigated the company, Biodiesel of Puerto Rico, which is already established. We were unable to interview Biodiesel of Puerto Rico. However, through research, we were able to find the information that was required for our analysis. We researched the market costs of biodiesel from Biodiesel of Puerto Rico. We also investigated biodiesel power generators to determine power output, cost, and fuel consumption. With this information, we conducted a cost analysis to determine if a biodiesel power plant is cost effective.
COST ANALYSES

Our project group performed cost analyses for solar power, composting, and biodiesel. We used net present value to determine whether or not solar power, composting, and biodiesel should be implemented within the Park. The equation for net present value is as follows: $PV = \frac{(\text{Cash Flow Year } t)}{\left(1+\text{r}\right)^t}$. “PV” in the equation represents present value, in which the units are dollars. “Cash Flow Year $t$” is the amount of money that will be saved each year, accounting for the interest rate. The “r” in the equation represents the rate of return, or interest rate. The “t” represents the number of years.
CHAPTER 4: RESULTS

This project focused on establishing a waste management system within the Punto Verde Park. We also investigated ways in which energy can be conserved by incorporating green roofing. Lastly, we analyzed all potential renewable energy sources to address the Park’s energy usage concerns. We wanted to ensure that the Punto Verde administration has enough information to consider these technologies at a later date. Our evaluation relied heavily on the costs and benefits of our solutions for the Punto Verde Company.

WASTE MANAGEMENT

Estimating Waste Production

We interviewed Henry Flores, a representative from Consolidated Waste Services Incorporated, to determine how much waste will be produced per person in the Park. Based on his past experience, he estimated that the Park will produce 0.5 pounds of waste per person per day. We calculated the amount of waste per week in pounds as well as in tons. The Park will be open three days a week in the low season and four days a week in the high season. An estimate for the amount of waste produced in both the high and low seasons can be seen in Table 1 below. See Appendix F for information about how park attendance was estimated.
Table 1. Amount of Waste Produced in the Park

<table>
<thead>
<tr>
<th></th>
<th>Park Attendance</th>
<th>Waste Produced in the Park</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily</td>
<td>Weekly</td>
</tr>
<tr>
<td><strong>Low Season</strong></td>
<td>5,000 people/day</td>
<td>15,000 people/week</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High Season</strong></td>
<td>7,500 people/day</td>
<td>30,000 people/week</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Information calculated from estimates provided by Punto Verde and Henry Flores.

**Waste Disposal**

Based on our research and our interview with Henry Flores, we determined that 40 percent of the Park’s waste can be composted, 20 percent recycled, and 40 percent sent to landfills. See the recycling and composting sections below for information on how these percentages were obtained. At a maximum of 7.5 tons per week, Punto Verde needs a dumpster that will hold 40 percent of this waste, or 3.0 tons per week. There are 1.48 cubic yards in a ton, so the Park will have 4.44 cubic yards of waste from Friday to Sunday. In order to manage this amount of waste, the Park needs to purchase one dumpster that holds eight cubic yards of waste. We arranged for Consolidated Waste Services Incorporated to pick up the Park’s waste twice a week. The cost for the pickup service, including the price of the dumpster, is $267 per month. Flores also suggested that after the Park has been open for a month, the representatives from Punto Verde re-estimate the number of people that visit the Park over then next few months so that adjustments can be made to the service. This is to account for the initial popularity of a newly opened Park.
The goal of Punto Verde is to compost all of the kitchen scraps as well as yard waste produced in the Park. Based on our research, 40 percent of the waste produced in the Park will be compostable (Michaels, 1994). At a maximum of 7.5 tons per week, Punto Verde will be able to compost 40 percent, or three tons per week. Based on the amount of waste produced, the composting companies that we interviewed determined that an in-vessel composting system that can hold 0.5 tons per day will be able to process the amount of waste produced in the Park.

We determined that an in-vessel composting system would best fit the needs of the Park because it can process all types of foods, while concealing odor and keeping away unwanted animals. The in-vessel composter regulates oxygen levels, moisture content, and turning of the compost so less labor is required for the upkeep of the system. We researched vendors and found that the price range for an in-vessel composter does not fit into Punto Verde’s budget. Punto Verde administrators did not allot any money for composting, while the cost of a one ton composter can range from $110,000 to $350,000.

See Table 2 below for a comparison of in-vessel composting companies.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Bin Size</th>
<th>Cost</th>
<th>Throughput</th>
</tr>
</thead>
</table>
| Hot Rot Systems  
  Hot Rot 1206 | 23’ long,  
  9’ wide, 9’ tall | $110,000 | 0.5 ton per day, 3-5 day retention time |
| Hot Rot Systems  
  Hot Rot 1509 | 47’ long,  
  19’ wide, 19’ tall | $205,000 | 1 ton per day, 5-7 day retention time |
| Augspurger Komm  
  Engineering  
  Mobile Mulchers | 21-50’ long,  
  6-8’ wide, 8’ tall. | $350,000 | 10-100 yd³, 20-30 day retention time |

We also decided to investigate small scale backyard composting. Table 3 below shows a comparison of small scale composting bins.
<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Bin Size</th>
<th>Cost</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Air Gardening Compost Tumbler</td>
<td>32” wide, 44” high</td>
<td>$170</td>
<td>55 gallons</td>
</tr>
<tr>
<td>Gardener’s Supply Company Tumbling Compost Mixer</td>
<td>24’ high</td>
<td>$150</td>
<td>55 gallons</td>
</tr>
</tbody>
</table>

We also designed signs that would educate the children about the benefits of composting and the composting process. The signs describe that as food scraps and yard waste go into the compost bin, oxygen, water, and organisms break down the waste into usable soil. See the chapter on conclusions and recommendations for the composting signs.

**Composting Cost Analysis**

The cost of operating a composter is related to its electricity costs. In order to obtain a general estimate of how much electricity a composter uses, we analyzed the annual energy requirements of the Earth Tub in-vessel composter. We used this composter as a benchmark because information about its energy usage was readily available. The Earth Tub uses 1080 kilowatt-hours per year and can process up to 0.7 tons of compost per week (Green Mountain Technologies, 2006). The Hot Rot 1206 composter can process up to three tons of compost per week. Assuming the same kilowatt-hours are required per ton of compost, the power usage of the Hot Rot 1206 can be estimated at approximately 4600 kilowatt-hours per year. Assuming seventeen cents per kilowatt, the operation will cost the Park approximately $800 per year in electricity.

It costs $534 per month to throw away 100 percent of garbage in the Park. This garbage disposal consists of two dumpsters in the Park being emptied twice a week (H.
Flores, personal communication, April 10, 2007). We estimated that 40 percent of the Park’s solid waste will be composted. This means that we will only need one dumpster emptied twice a week to dispose of waste, which will save the Park 50 percent of the garbage costs. This is equivalent to $267 per month or $3,204 per year.

According to the Urban Landscape Series (2006), compost is sold at $10.00 to $28.00 per cubic yard or $6.76 per ton (1.48 yd$^3$ in a ton), assuming the compost is safe to use. See Table 4 below for guidelines on safe compost.

**Table 4. Compost guidelines**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon/Nitrogen Ratio</td>
<td>6 minimum - 25 maximum</td>
</tr>
<tr>
<td>Ammonia Levels, % of Total</td>
<td>10 % maximum</td>
</tr>
<tr>
<td>Percent Moisture</td>
<td>20 % minimum - 40 % maximum</td>
</tr>
<tr>
<td>pH</td>
<td>5.5 - 8.5</td>
</tr>
<tr>
<td>*Soluble Salts (mmhos/cm)</td>
<td>10 maximum</td>
</tr>
</tbody>
</table>


The Park will produce three tons of compostable waste per week in the high season, which equals 156 tons per year. At $6.76 per ton, the Park will gain $1,054.56 per year from selling compost (Sustainable Urban Landscape Series, 2006). With $3,204 per year saved on garbage disposal costs and $1,054.56 saved on soil, the Park will save a total $4,258.56 per year. Accounting for the $800 to power the composter, the Park will save $3,458.56 per year.
We determined how many years it will take to match the initial investment of $110,000 using the net present value equation and a 5 percent rate of return. The equation for the net present value was used to calculate the money saved by using an in-vessel composter as opposed to disposing of solid waste. The cash flow that was calculated for the present day was $3,460 per year. With the t-value measured in years, the present value was calculated to determine when the initial investment is paid off. According to the Kansas State Research and Extension (2006), it is accurate to assume a five percent discount rate for composters, an r-value of 0.05. Accounting for the money saved on garbage disposal, money earned by selling compost, and money lost due to electricity, the in-vessel composter will save the Park $3,460 per year. Figure 3 below shows the net present value for composting.
RECYCLING

By interviewing the directors of Punto Verde, we determined that their goal was to recycle and compost 100 percent of the waste that they produce. They would like to recycle paper goods from the food court and plastic bottles. The only things that cannot be recycled are plastic utensils. Based on the amount of recyclable materials that the Park will produce, we determined that only 20 percent of the Park’s solid waste will be recyclable.

We interviewed Grupo Comunitario de Reciclaje in order to set up a recycling program for the Park. Grupo Comunitario de Reciclaje’s complete proposal will cost Punto Verde $4,500 (Grupo Comunitario de Reciclaje, 2007). The first part of the proposal consists of training the Park’s employees to sort and work with recyclable
materials. Sensitizing training costs $50 per person and materials education costs $25 per person.

The second part of Grupo Comunitario de Reciclaje’s proposal consists of ways in which recycling programs can be incorporated within the Park. They proposed creating a fair on reuse and recycling in the Park as a temporary exhibit for $3000. They also offer a less expensive, $1,500 activity for the Park in which children can come to the Park and make crafts out of recycled materials. The $1,500 activity has a limited capacity of twenty-five people.

The last part of the proposal consists of the management of the Park’s recyclable materials. The company charges $125 for every pickup of their 30 cubic yard container, which can hold paper, cardboard, plastics, glass, and aluminum. Any cardboard-only pickup will cost $100, unless there are twenty or more bales, whereby the pickup is free. See Table 5 for the reimbursement prices offered to Punto Verde for different recycled materials.

<table>
<thead>
<tr>
<th>Money Punto Verde gets back ($ per ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newspaper</td>
</tr>
<tr>
<td>Cardboard</td>
</tr>
<tr>
<td>Plastic, Glass, Aluminum Mix</td>
</tr>
<tr>
<td>Plastic</td>
</tr>
<tr>
<td>Aluminum</td>
</tr>
</tbody>
</table>

ENERGY USAGE

One of the concerns that Punto Verde had with their development of the Park was its energy usage. The Park administrators wanted to find the most feasible way to use clean power sources as well reduce the demands for energy in the Park’s daily operations. Our project group investigated the possibilities of green roofing, and renewable energy sources to address Punto Verde’s energy needs. One of Punto Verde’s top energy concerns was the constant use of air conditioning that will be needed in the main office building. The office building will be constructed in an open section of the Park, leaving the building exposed to the sun’s rays.

With the cost of electricity on the Island being seventeen cents per kilowatt hour (J. Naveira, Punto Verde representative, personal communication, April 10, 2007), lowering the Park’s use of power from the utility grid will have a significant impact on the Park’s budget in the future. Based on information collected by the representatives of Punto Verde, the Park will use an average of 175 kilowatt while in operation (J. Naveira, personal communication, April 10, 2007). The Park is projected to be running electricity approximately 300 hours each month, making the Punto Verde Park electrical bill close to $8,925 per month. The Park will save $51 per month for every kilowatt that the Park does not use.

GREEN ROOFING

We investigated green roofing for the purpose of energy conservation within the Park. After discussing the possibility of green roofing with Punto Verde administrators,
we decided to focus our green roof research on the administrative office and food preparation area.

In order to determine how much weight would be added to the roof, we first determined what type of green roofing would be feasible for the building. Our research indicated that, in the interest of temperature control within the Punto Verde office building, both extensive and intensive roof designs would work effectively for our needs. The plant growth on the top of a roof has extremely little effect on a roof’s “R,” or “heat penetrability resistance” value. See Appendix B for information about these values. A green roof’s R value is dependent mainly on soil depths. While deep soils have the ability to support larger plant life, it is not necessary that larger plants be grown (R. Clark, personal communication, April 4, 2007). Therefore, we determined that the roof could potentially hold either extensive or intensive green roofing. We verified from HydrotechUSA that intensive roofs are generally heavier, require more maintenance, and are more expensive than extensive roofs. Punto Verde also did not budget for a green roofing project inside of the Park. For all of the previously mentioned reasons, we chose to investigate the installation of an extensive system.

With data from HydrotechUSA, we determined that an extensive green roofing system would add at least an additional 43.05 pounds per square foot to the roof. The entire roof is approximately 2,500 square feet. Based on these values, we determined that the building would need to support an additional 107,500 pounds.

By interviewing the building’s architect, Evelio Pina, and the Park’s landscape architect, Vilma Blanco, we discovered that the ground that the building will be constructed on cannot support the weight of a green roof. This information was further
reinforced by the Geotechnical Exploration report submitted by Lourdes Rodríguez Cuadrado, P.E. of the Jaca and Sierra Testing Laboratory. Cuadrado (2007) states that the soil type is unstable and may lead to building collapse if excessive weight is added to the support columns. Cuadrado recommends planning the building support system to hold a maximum of forty tons per support column. Using the estimated weight of the green roof provided by HydrotechUSA, the entire 2,500 square foot roof would have to support an additional fifty-three tons. Based on this large increase in weight, the Punto Verde architects do not think it will be feasible to consider using any form of green roof for the main office building.

We also investigated implementing a green roof on a smaller section of the building. This area is only 250 square feet and does not have a second floor that adds to the weight of the building. The additional weight of the green roofing for that section is 10,750 pounds. Pina informed us that although the section can support the weight, there would not be many people walking through the area. Therefore, a green roof in that section would not be beneficial as an educational attraction.

**SOLAR POWER**

Solar power is one of the most promising possibilities for renewable energy within the Punto Verde Park. Our project group decided to investigate photovoltaic cell technology. Photovoltaic cells are the most portable, compact, and simple way to generate solar-electric power. Since they are the most common source of solar power generation, they will be readily available for any park patrons interested in adopting this renewable energy system as their own.
Research has shown us that the average complete photovoltaic power generation system costs close to $7 per watt. While this price may be tolerable for small scale solar power needs, it is too expensive for the Punto Verde Park. Instead, we arranged a prospective business deal with a distributor of renewable energy technology based in Murrieta, California. Through this company, we arranged for a photovoltaic assembly that will cost approximately $5 per watt. Based on our research of different vendors, we decided that this is the most feasible option. Table 6 shows the cost of a complete one kilowatt solar system, including inverters and wiring, from several different companies.

Table 6. Cost of Solar Systems

<table>
<thead>
<tr>
<th>Company</th>
<th>Cost ($/kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5,000</td>
</tr>
<tr>
<td>B</td>
<td>10,000</td>
</tr>
<tr>
<td>C</td>
<td>5,850</td>
</tr>
<tr>
<td>D</td>
<td>8,000</td>
</tr>
<tr>
<td>E</td>
<td>*5,556</td>
</tr>
</tbody>
</table>

*Cost of panels alone

According to Table 6, it is evident that company A is offering the lowest prices for a complete system. Javier Naveira estimated that the Park will use an average of 175 kilowatts of power. This estimate was based on research that Naveira did by comparing their facility to facilities of similar size. With an average of 175 kilowatts of power needed, Naveira also expected the Park to need up to 225 kilowatts when the Park is extremely busy. Any system designed to provide power to the Park needs to be able to handle that maximum load. A safely designed system would be capable of producing 250 kilowatts.

The panels that company A are offering at a reduced price are BP Solar 170 Watt photovoltaic modules. See Appendix H for information regarding product specifications. Each of these modules has a face area of 5.2 feet by 2.6 feet, and weighs 2.4 pounds per square foot. To provide enough power for the entire Park’s needs, the Park would need approximately 1,500 of these solar modules. Every five kilowatts added to the system
require a five kilowatt inverter to convert the solar energy into usable electrical power. The entire system would cost close to $1,300,000, would weigh close to 49,000 pounds, and would require 20,397 square feet of available space in the Park. These space and budget requirements are not feasible for the Punto Verde Park at this time.

If the panels were used to assist powering an isolated section of the Park, such as the Punto Verde office building, a more feasible system can be designed. The office building will have many energy needs ranging from lighting to refrigeration. This will also be where the Park’s usage of air conditioning will be necessary. Central air conditioning needs for the Punto Verde office are estimated to be close to 16 kilowatt-hours per day. This estimate is based on a benchmark set by a 16 SEER Amana air conditioner. We chose this model because information about the product was more accessible than others and has a high efficiency rate. See Appendix I for information regarding SEER values and product specifications. A ten kilowatt solar system could be used to easily supplement the load required by the building’s air conditioning each day.

A ten kilowatt solar system will only require approximately 816 square feet of space, and cost $52,000. Compared to the office building’s 2,500 square feet of rooftop space, there is a sufficient amount of space for the installation of a ten kilowatt solar system using company A’s product. This system would also weigh close to 2000 pounds, which could be supported by the roof of the main office building. The Punto Verde Company has allocated $213,793 towards the use of solar technology in the Park. This money is budgeted for solar light poles and bollards, which can cost approximately $500 per unit. These light poles generally use 0.02 watt LEDs for the light source. Assuming there are ten LEDs in one bulb, a solar light pole produces power at $2,500 per watt,
which is 500 times more expensive than the larger solar array offered by the California distributor.

**Solar Power Cost Analysis**

Weather conditions have an effect on how much power solar panels generate in a year. In a worst case scenario, solar panels will average five hours of solar energy collection per day in Puerto Rico (Alternative Energy, 2006). In a best case scenario, the panels will average ten hours of solar energy collection per day (Alternative Energy, 2006). According to Javier Naveira (2007), the annual electricity cost for the Punto Verde Park, if purchased from the electric company, is approximately $9,000 per year.

Assuming a worst case scenario, which is five hours of sunlight collection per day, solar panels from Company A will save Punto Verde $3,060 per year. The best case scenario would save $6,120 per year. The most feasible scenario, which is nine hours of sunlight collection per day, will save Punto Verde $5,510 per year. These values were obtained by multiplying the amount of energy output per hour, ten kilowatts, by the number of hours per day the panels are collecting sunlight. This number was multiplied by the price per kilowatt-hours of electricity in Puerto Rico, seventeen cents per kilowatt-hours. This number was then subtracted from the $9,000 per month that the Park is estimated to use if they bought electricity from the electric company. The initial cost of our proposed solar panel power system is $52,000.

**Net Present Value.**

Discount rates vary depending on how risky the project is. According to the International Energy Agency (1998), the discount rates for sources that generate electricity are almost always between 5 and 10 percent. According to the California
Public Utilities Commission (2006), it is accurate to assume an 8 percent discount rate for solar power.

We determined how many years it will take to match the initial investment of $52,000 using the net present value equation and the 8 percent rate of return. The equation for the net present value was used to calculate the money saved by using solar panels as opposed to electricity. The cash flow calculated for present day was $5,140 per year. The t-value ranges from zero to twenty-five years. The initial investment is paid off within this range. The r-value is 0.08, which is equal to the 8 percent rate of return. The solar panels will save the Park between $3,672 and $6,120 every year.

In a feasible scenario, assuming nine hours of sunlight collection per day, solar panel power would be a reasonable investment, based on cost alone, for the Park. By investing $52,000, after twenty-five years, Punto Verde will gain approximately $7,000 on top of their original investment. Figure 4 below shows the net present value for solar power.
BIODIESEL

We evaluated a biodiesel alternative to the Park’s energy production as well. We decided that our group would investigate a biodiesel energy production plan that could supply power to the entire Punto Verde Park. We had three critical concerns when investigating this possibility. The first was whether or not the power generators that Punto Verde would need were going to be easily installed and operated. The second was whether or not these generators would be compatible with biodiesel fuel. The third was the expected cost of the biodiesel that would be available to Punto Verde.

The Punto Verde Park has limited space for equipment such as large diesel generators. Since many generators come with weatherproof casings, the generator can be placed outside and Punto Verde would not need to find space for the generator inside of any of their facilities. However, a special concern that Punto Verde should address is the
noise regulations which are currently in place by the Environmental Quality Board (EQB). The Punto Verde Park qualifies as a Class II location. See appendix J for more information on zone definitions. According to the EQB, class II zones can not produce noise levels greater than seventy decibels more than 10 percent of the time. The generators that we investigated for the Park have noise levels of as much as seventy decibels. Punto Verde administrators need to make sure that the generator is placed at least twenty-five feet away from park patrons.

We contacted diesel generator vendors Go Power and Jobsite Generators to ask them about their products. Chalice Johnson, of Go Power, informed us that biodiesel would not be applicable in any of the generators that they sell. Connie Carver, of Jobsite Generators, told us that biodiesel can possibly be used as a power source for their generators. However, Carver warned that using biodiesel fuel in a generator comes with several risks. First, there will be a 5 to 7 percent loss in horsepower, requiring greater fuel consumption than with diesel. Second, biodiesel may cause components of the motor, such as filters and fuel injectors, to fail more quickly. A generator that will produce 240 kilowatts comes with sensors that help the generator to monitor its power production and need for fuel consumption. The generators are easily installed by connecting leads directly to Punto Verde’s power grid.

As a benchmark for analysis, we used a 240 kilowatt biodiesel generator with a Scania DC12-54 engine. We chose to use this model generator because it is inexpensive and made specifically for use with biodiesel. For this model, using biodiesel will not void the generator’s warranty. See Appendix K for product specifications. Based on the information we collected from both biodiesel companies we determined the costs of
biodiesel. We estimated that the Punto Verde Park could produce its own power for as little as four cents per kilowatt hour. This price is thirteen cents cheaper than that of the power company.

**Biodiesel Cost Analysis**

We identified a biodiesel generator that has an initial cost of $48,482. At maximum power, the generator will produce 240 kilowatts. Assuming nine hours of operation per day, the generator will produce 2,160 kilowatt-hours. In a reasonable scenario, the Park only needs 175 kilowatts per nine hour day. According to Javier Naveira, the Park will be in operation approximately 300 hours per month. Therefore, in one month, the Park will need 175 kilowatts multiplied by 300 hours per month, which equals 52,500 kilowatt-hours. This is equivalent to 630,000 kilowatt-hours per year.

The power company in Puerto Rico sells energy for seventeen cents per kilowatt hour. We multiplied this cost by the amount of energy needed to operate the Park in one year and estimated that the annual electricity cost from the electric company will be $107,100. The current cost of biodiesel, if purchased from Biodiesel of Puerto Rico, is sixty-one cents per liter or $2.31 per gallon (Feliú-Mojer, 2007).

To produce 240 kilowatt-hours of power, 16.35 gallons of biodiesel are needed for the Park. To determine the percent power required by the generator, we divided the estimated 175 kilowatts needed by the maximum capacity of 240 kilowatts. We estimated that the generator will need to be operated at 73 percent power.

We estimated that 73 percent of the maximum fuel consumption is 11.9 gallons per hour. At the cost of $2.31 per gallon, we estimated that biodiesel from Biodiesel of Puerto Rico would cost $27.49 per hour to run the generator. The cost per kilowatt hour
from using this company’s product would be 15.7 cents. This value is still less expensive than the seventeen cents per kilowatt-hour established by the power company.

As determined above, the Park will need about 630,000 kilowatt-hours per year to operate. This will cost Punto Verde $98,910 if biodiesel is purchased from Biodiesel of Puerto Rico. In order to determine the annual savings from using biodiesel, we subtracted the cost of operating a biodiesel plant for one year, $98,910, from the amount would be spent on electricity, $107,100. Based on this calculation, the annual savings from using a biodiesel generator in the Park will be approximately $8,190.

We performed a net present value cost analysis for biodiesel to determine when the initial investment for a biodiesel generator will be paid off. An 8 percent rate of return was used. Figure 5 below depicts how much profit will be made from the biodiesel generator after a number of years from the time when the initial investment of $48,482 was made.
Figure 5. Biodiesel Net Present Value
CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

COMPOSTING

Recommendations:

1. Purchase an in-vessel composter through donations or loans.
2. Use soil produced from the composter for small business development.
3. Use small scale backyard composting as an educational tool.
4. Become a local supplier of Genpack compostable food ware.

We determined that an in-vessel composter can be used to compost the Park’s food and yard waste. The Hot Rot 1206 composter, at $110,000 will be able to process the Park’s estimated waste production. However, the representatives from Punto Verde have not allotted more than $50,000 for a composting unit. Also, our cost analysis shows that at $110,000, it will take over 31.8 years to pay off the initial cost of the composter. Any payback of over ten years is not feasible. We recommend that Punto Verde representatives create a project to get a composter donated to them or investigate loan options. Composting is an important part of the Parks waste management. It will reduce the amount of solid waste that must be sent to landfills, which is a major step in solving the Island’s solid waste problem.

If the Park takes advantage of an in-vessel composter, we recommend that the Park use the soil produced by the composter to promote small business development. Vendors can create their own business selling the soil.

An in-vessel composter will need to be placed in an area of the Park that is not visible to park patrons. We recommend that small scale backyard composting be implemented as an educational attraction within the Park that inspires the visitors to use
these technologies themselves. Figure 6 below shows a sign that teaches children how composting works.

**Figure 6. Display on How Composting Works**


We also recommend that a nearby display explain what is happening inside a composting unit. Figure 7 is an example of this sign.
Figure 7. What Happens Inside Composting Units Display

Qué Sucedé Adentro
What Happens Inside

Note. Figure was adapted from another composting project report (Bourgault et al., 2005).

Lastly, we recommend that Punto Verde purchase plates cups and other paper goods from Genpak. These paper goods are made out of corn starch, and are fully compostable. The use of these plates will reduce the amount of waste that will need to be sent to landfills. If Punto Verde acts as a supplier for these products, they will be able to make a profit as well encourage other business to compost.
RECYCLING

Recommendations:

1. Work with Grupo Comunitario de Reciclaje to establish a recycling program within the Park.
2. Use cans instead of soda fountains in order to take advantage of aluminum reimbursement rates.

Although the representatives of Punto Verde would like to recycle 100 percent of their solid waste, we have determined that this amount is not feasible. Punto Verde will be able to recycle plastic bottles, cans, and paper which we estimate will account for about 20 percent of their waste. We recommend that the representatives from Punto Verde work with Grupo Comunitario de Reciclaje to establish a recycling program within the Park. Grupo Comunitario de Reciclaje is a worker owned company that has a pre-existing affiliation with Punto Verde. The mission of Grupo Comunitario de Reciclaje complements the mission of Punto Verde.

We also recommend that the Park uses aluminum cans instead of cups. The Park will receive a reimbursement from using aluminum cans that they will not receive from using cups. Also, can usage decreases the amount of waste that needs to be composted.

GREEN ROOFING

Recommendations:

1. Use an educational display to educate park patrons on the benefits of green roofing.
2. Put small scale green roofing on future buildings or kiosks.
We determined that green roofing for the Park’s office building is not feasible because the soil cannot support the weight of the green roof. We recommend that a display be used as an educational tool instead of installing an actual green roof. The design should be as realistic as possible. We also recommend that the representatives of Punto Verde consider implementing green roofing on new buildings and kiosks as new plans develop.

The display we are recommending should include a few square feet of completed green roofing. It should be raised off of the ground in order to show that the waterproofing is effective. The corners should also be cut with glass over them to clearly reveal the layering necessary for green roofing. We also recommend colorful signs to go around the display. Figure 8 is a potential sign on green roofing for the Park. It displays green roofing’s ability to reduce the urban heat island effect. However, we do not recommend using the terminology “urban heat island effect” because of the age group of the children visiting the Park.

Figure 8. Green Roofing Reducing the Urban Heat Island Effect Sign
SOLAR POWER

Recommendations:

1. Invest in solar power when the net metering legislation is passed.

2. Stress the use of solar power as an educational tool.

   Current policy in Puerto Rico says that it is illegal for local power generation sources, such as solar energy, to be used in the same electrical system as energy that is provided by the AEE. See Appendix L for information regarding that legislation. Even though solar energy is a clean and unlimited power source, it is not consistent enough to use as an independent power supplier. For this reason, Punto Verde will not be able to feasibly rely on solar power alone to provide power for any of its needs.

   It is our project group’s recommendation that representatives from Punto Verde withhold at least $75,000 of its solar light posts budget until the proper legislation concerning net metering practices is passed. At that time, it is our recommendation that representatives from Punto Verde install a solar powered grid tie system for the Punto Verde Park. We recommend using company A, Global Energy, of Murietta, California. We are recommending their equipment because of the prices that they have offered to the Punto Verde Park. See Appendix G for contact information.

   We also recommend that solar power be used as an educational tool. Park patrons should be made aware of the Park’s use of solar power and shown how beneficial the system is. This will encourage patrons to use cleaner sources of energy.
BIODIESEL

Recommendations:

1. Punto Verde should not purchase a biodiesel generator until more information is known about the fuel supply, market price, estimated increase of market price, and fuel quality.

2. Punto Verde should keep up to date on biodiesel fuel companies on the Island.

3. If Punto Verde chooses to pursue biodiesel technology, the Park needs to ensure that the biodiesel provider commits to at least 5,000 gallons of fuel per month.

Our project group concludes that installing a diesel generator in the Park and fueling it with biodiesel is the Park’s most cost effective option for power generation. Since biodiesel is an environmentally friendly alternative to fossil fuels, we feel that the use of this technology would still be within the eco-sensitive mission of the Punto Verde Park. Encouraging its use throughout the Island would improve environmental concerns worldwide.

However, we recommend that the Punto Verde administrators not immediately invest in a biodiesel generator for the Park. Information regarding consistency of the fuel supply, estimated increase in fuel prices, and fuel quality is not currently available. This information is crucial for the establishment of a biodiesel power generation plan and needs to be determined before Punto Verde considers implementing this technology.

We recommend that Punto Verde remain up to date on information regarding the status of biodiesel producers on the Island. We also recommend that Punto Verde make certain that they have a commitment of at least 5,000 gallons of fuel per month. Punto
Verde also needs to have reassurance from the biodiesel producer that their product will comply with the biodiesel fuel guidelines set by their generator’s manufacturers.
APPENDIX A - ABOUT PUNTO VERDE

Punto Verde is a community-based, economic development project created in 2000. It is also a worker-owned and operated corporation. The goal of Punto Verde is to give low wage and unskilled workers a chance to take advantage of training, development, and wealth opportunities. Punto Verde has decided to work with the residents of the Nemesio Canales, Canteras, and Barrio Obrero communities of San Juan.

Punto Verde worked with Omega Overseas Investments to set up an investment business. As a worker-owned corporation, Punto Verde did not have to pay taxes for this. Punto Verde borrowed money at one rate and loaned money at a higher rate to other businesses at the same time. The profit from the investment business is used to fund the building of the Punto Verde Park.

Punto Verde is currently working on building an educational, eco-friendly children’s park to meet their goals. The construction employs residents of these communities. After the construction phase, jobs in the Park will also employ residents of the same areas. As a worker-owned organization, Punto Verde is owned and controlled by its employees. Punto Verde also encourages autonomous small business development in the Park by giving economic aid to approved employees. The organization chart below explains the hierarchy and responsibilities of the administrative employees.
Figure 9. Punto Verde Organization Chart

Note. Figure adapted from information provided by Punto Verde
APPENDIX B – GREEN ROOFING TECHNOLOGIES

The most effective green roofs are put together in layers (Velazquez, 2005). The topmost layer of a green roof holds the vegetation. The next three layers are designed to drain and store water, guard the roof from roots, and act as insulation. The last layer acts as a waterproof barrier (Velazquez, 2005). These layers work in conjunction to both maintain the green roof and the building. Figure 10 below shows the different layers of a green roof.

Figure 10. Green Roofing Layers


Green roofs have particular drainage needs that limit flexibility in choosing a soil for plant growth. The soil needs to be able to allow large quantities of water to flow
through it. This water can then be stored in the roof’s water reservoirs while the excess water can drain freely off of the roof’s surface. The soil is layered with topsoil, fertilizer (such as compost), and an inorganic medium. The inorganic medium can provide aeration and prevent the soil from compressing in on itself (greenroofs.com, 2007). Thickness of this growing layer is dependent on the needs of the plants that are to be incorporated.

The sub-soil irrigation system is self regulating. These water storage and drainage systems can be made out of gravel (Velazquez, 2005). However, modern green roof makers have moved towards man-made, specially designed water storage and drainage systems. These specially engineered systems are normally made out of plastic composites glued to fabric barriers. The plastic materials are much lighter than the equivalent amount of gravel that it would take to give the same quality of drainage, and are also less expensive (American Wick Drain Corporation, 2006a). They are geometrically designed to enhance aquatic flow within a quarter to half an inch of space. The fabric barriers are designed to protect the plastic core from dirt particles which would impede the plastic’s ability to drain water (American Wick Drain Corporation, 2006b).

Root barriers are necessary to protect a building by keeping plant growth under control. Without root barriers, roots will migrate through the underlying structures to reach nutrients and water sources. The penetration of roots into the roof’s root barrier can cause damage to the roof’s waterproofing system (Carlisle, 2002). The bottom layer of a green roof, the waterproofing layer, is used to keep water from the building surface. Sedentary water on the surface of the roof can cause many problems for the building structure (Salmon, 1995).
Insulation is not an essential layer for green roofing, but helps to provide additional energy conserving benefits (Velazquez, 2005). The water that is saved in the roof’s upper layers has the potential to alter the temperature inside of a building (Velazquez, 2005). Insulation retards this process by preventing rapid heat exchange, into or out of the building, between the building’s surface and the water above. Therefore, green roofing insulation could conserve energy spent on air conditioning.
APPENDIX C – RECYCLING AND SOLID WASTE TECHNOLOGIES

There are many technologies used throughout the world concerning the global solid waste problem. The types of solid waste management are landfilling, waste incineration, anaerobic digestion, and recycling (Waste Disposal, 2007).

Waste incineration is a waste treatment technology that involves the combustion of waste at high temperatures. Incineration and other high temperature waste treatment systems are described as "thermal treatment." In effect, incineration of waste materials converts the waste into heat that can be used to generate electricity, sends gaseous emissions to the atmosphere, and makes residual ash (Chemical Industry, 2006). Hazardous waste incinerators were implemented by the combustion industry to solve the hazardous waste crisis. Regulations on hazardous waste landfills require specific treatment, transportation, storage, and disposal. This makes hazardous waste landfills expensive. Because of this, incineration was promoted as an economic alternative to landfilling (Chronic Illness and Health Maintenance, 2007).

Anaerobic Digestion is a process by which organic waste is broken down in a controlled, oxygen-free environment by naturally occurring bacteria in the waste material. Large amounts of methane gas are released from this process. If properly handled, methane gas can be collected and used as a renewable energy source. Anaerobic Digestion is a form of composting. Generally, the term “composting” is referring to aerobic composting. Aerobic composting makes carbon dioxide, but not methane gas. Composting is considered safer than anaerobic digestion because of the amount of methane created in anaerobic digestion (Waste Research, 2007).
Landfilling, a method in which waste is put into carefully engineered, lined depressions is the most common waste disposal method (Basics of Landfills, 2003). Incineration and anaerobic digestion are less common because they emit gases that are harmful to the environment (Waste Disposal, 2007). Due to limited space, one landfill is a short-term solution that will last for a limited amount of time. After filling one landfill, new landfills need to be made to dispose of waste. Many places that used to rely on landfills alone now turn to recycling to reduce the amount of solid waste that is put into landfills. Recycling will slow down the process of the filling of landfills so they can last much longer (EPA, 2006b).

Recycling is the processing of materials so that they can be reused to make different things (Merriam Webster Online, 2007). According to the EPA (2006e), recycling is a tool that is beneficial to the environment. By recycling, there is much less waste being placed into landfills. Recycling also reduces the amount of waste that needs to be incinerated.

Materials that can be recycled and reused include aluminum, cardboard, glass, paper, steel, tin, and plastics (Water, Waste and Recycling, 2007). These materials can be brought to a collection location or be collected by waste service companies on a weekly basis. All materials that are brought to recycling plants are broken down so that they can be reused to make a new product.

Figure 11 below is an example of a waste hierarchy chart. It describes the least to most favorable options for the environment of how to deal with solid waste. Disposal is the least desired method because the waste must be placed into a landfill or incinerated.
Recycling and reusing are important if a lot of waste is being produced. The most environmentally favored options are minimization and prevention of waste.

**Figure 11. Waste Hierarchy**

APPENDIX D – COMPOSTING PROCESS

Composting relies on microorganisms to decompose organic materials into a dark, soil-like substance known as humus (http://vegweb.com/composting/). In this process, chemical reactions and organisms such as bacteria, fungi, insects, and worms decompose the material. As the decomposition progresses, heat is produced causing the decomposition to occur even faster (North Carolina Department of Health and Environmental Control [DHEC], 2007). According to the EPA, there are five major factors to consider when composting. These include the balance of nutrients, particle size, moisture content, oxygen flow, and temperature (EPA, 2006f).

Nutrient Balance

In order for a compost to be successful, it must contain a balance of green and brown organic materials. Green materials, consisting of grass, food scraps, and manure, contain nitrogen. Brown materials, consisting of dry leaves and wood chips, contain carbon (EPA, 2006f). According to compostguide.com, the compost should ideally have a 3:1 ratio of carbon to nitrogen materials. Too much carbon can cause the pile to decompose too slowly, while too much nitrogen can cause strong odors (http://vegweb.com/composting/). Table 8 below shows a complete list of materials that can be composted and the category it falls into. Table 9 below shows a list of materials that should not be composted, and the reason why. All materials should be chopped, shredded, or ground in order to increase the surface area in which microorganisms can feed.
Table 7. Materials that can be composted

<table>
<thead>
<tr>
<th>Green Material (Nitrogen Sources)</th>
<th>Brown Material (Carbon Sources)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure</td>
<td>Ash</td>
</tr>
<tr>
<td>Coffee</td>
<td>Bread</td>
</tr>
<tr>
<td>Flowers</td>
<td>Coffee</td>
</tr>
<tr>
<td>Fruits and Vegetables</td>
<td>Dry Leaves</td>
</tr>
<tr>
<td>Grass</td>
<td>Egg Shells</td>
</tr>
<tr>
<td>Green Leaves</td>
<td>Hair</td>
</tr>
<tr>
<td></td>
<td>Lint</td>
</tr>
<tr>
<td></td>
<td>Saw Dust</td>
</tr>
<tr>
<td></td>
<td>Straw</td>
</tr>
<tr>
<td></td>
<td>Tea Bags</td>
</tr>
<tr>
<td></td>
<td>Wood Chips/Shavings</td>
</tr>
</tbody>
</table>


Table 8. Materials that should not be composted

<table>
<thead>
<tr>
<th>Material</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy Products</td>
<td>Creates Odor, Attracts Pests</td>
</tr>
<tr>
<td>Diseased Plants</td>
<td>May kill helpful organisms</td>
</tr>
<tr>
<td>Fats, Oils, Lards</td>
<td>Creates Odor, Attracts Pests</td>
</tr>
<tr>
<td>Meat</td>
<td>Creates Odor, Attracts Pests</td>
</tr>
<tr>
<td>Pet Waste</td>
<td>May cause harm to humans</td>
</tr>
</tbody>
</table>


Types of Composting

According to the EPA, aerobic composting, which is decomposition in the presence of oxygen, is the most common type of composting. In this process, mesophile and thermophile microorganisms use oxygen, carbon, and nitrogen as nutrients, resulting in energy production. This energy production causes an increase in temperature of the composting pile. Mesophile organisms initially inhabit the compost from 50 to 116 degrees Fahrenheit. From 115 to 160 degrees Fahrenheit, thermophiles take over the decomposition. Compost piles reach a temperature of 140 to 160 degrees Fahrenheit within the core in approximately five days. This is not possible without oxygen. The
optimal oxygen level within the pile is approximately five percent. The EPA suggests that the pile be turned once a day in order to increase air flow within the pile. Moisture is another important factor in aerobic composting. The Backyard Composting Guide Suggests that the water content within the pile should be approximately 40 percent.

Although aerobic composting is most common, anaerobic decomposition, more commonly known as anaerobic digestion, takes place as well (http://aggie-horticulture.tamu.edu/extension/compost/chapter1.html). This process uses organisms that use nitrogen and phosphorus as nutrients, resulting in the release of organic acids, methane, and ammonia. The production of methane can be beneficial when used as a form of renewable energy in place of fossil fuels. The methane can be used for cooking, heating, cooling, lighting, and generating electricity (Appropriate Technology Transfer for Rural Areas, 2002).

There are two steps to the anaerobic digestion process. In the first step, the waste is converted into fatty acids by anaerobic bacteria known as acid producers. In the second step, the acid is converted into biogas by anaerobic bacteria know as methane formers (Appropriate Technology Transfer for Rural Areas, 2002). Anaerobic digesters use mesophilic bacterial for the decomposition process. Therefore, the temperature range required for anaerobic digestion is 90 to 110 degrees Fahrenheit. A twenty degree temperature variation can cause methane production to drop by 50 percent. The ratio of carbon to nitrogen for successful anaerobic digestion is 20:1 (Appropriate Technology Transfer for Rural Areas, 2002). This process is extremely useful in the composting of waste water and animal waste, where oxygen is not readily available (Golueke, 1977).
Composting Methods

There are many types of composting available. Choosing a composting method depends on the amount of space available and the amount of waste being produced.

Table 10 below shows three different types of aerobic composting and the advantages and disadvantages of each.

Table 9. Composting methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Backyard:</strong></td>
<td>Small scale, inexpensive, easy to operate, very little time or equipment</td>
<td>Cannot compost animal waste or large quantities of food scraps. Cannot repel</td>
<td>Up to a year</td>
</tr>
<tr>
<td></td>
<td>needed</td>
<td>odors or unwanted insects and animals</td>
<td></td>
</tr>
<tr>
<td><strong>Windrow:</strong></td>
<td>Large volumes of diverse waste, large scale, significant amount of compost</td>
<td>Requires frequent monitoring, Leachate can contaminate ground water, subject</td>
<td>3 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td>to enforcements</td>
<td></td>
</tr>
<tr>
<td><strong>In-Vessel:</strong></td>
<td>Large amounts of waste, little space, can accommodate any type of organic</td>
<td>Expensive, requires technical assistance</td>
<td>As little as a few weeks</td>
</tr>
<tr>
<td></td>
<td>waste, used year round, very little odor and leachate</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biodigester:</strong></td>
<td>Large volumes of animal waste, minimal odor, used year round, produces</td>
<td>Requires frequent monitoring, expensive</td>
<td>15 to 30 days</td>
</tr>
<tr>
<td></td>
<td>usable biogas</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX E – SODA BOTTLE TOY DESIGNS

In order to encourage recycling, we recommend that the Park incorporates fun interactive toys, which utilize recycled products. This appendix summarizes soda bottle design ideas, which could be part of a kiosk vendor’s products. The vendor would sell a product and the consumer would provide a standard plastic bottle. These bottles may be purchased in the Park’s food court or anywhere that sells standard soda bottles, such as grocery stores and vending machines. The customer simply needs to empty the bottle and remove the label.

**Bottle Rocket**

The Park vendor could supply bottle rocket stands that shoot a soda bottle in the air like a rocket. The stand will hold the bottle and push up the bottle with air. The customer jumps on a pad full of air, the air is pushed through a tube, and the bottle gets shot into the air. The picture is an example of a similar air rocket design (Amazon.com, 2007). We suggest that as many components of the rocket stand as possible be made out of recycled materials.

The Park or vendor would need to design and build these platforms. They could potentially use different sized bottles depending on the

![Figure 12. Bottle Rocket Design](http://www.amazon.com/Power-Rocket-Extreme-Performance-rockets/dp/B0002XHONG)

*Note: Picture taken from http://www.amazon.com/Power-Rocket-Extreme-Performance-rockets/dp/B0002XHONG*
design. The actual bottles sold in the Park should factor into the design.

Soda bottles being shot into the air could potentially become a liability. Therefore, employees working with these rockets should also ensure that all soda bottles are shot in a safe direction.

We also recommend that the Park considers employing someone to showcase larger rockets for display purposes, to be put in close proximity to the platforms designed above. This employee and his or her routine could provide an attractive addition to the Point of Return recycling area. The employee would need to study building plastic bottle rockets. The employee should experiment bottle rocket construction and research subjects including incorporating different amounts of water into rockets, using multiple bottles, utilizing compressed air or other gases, finding a safe landing area, and safety procedures. Any larger rockets need to be tested for safety before launching them in the Park during operational hours.

**Bird Feeder**

To make a bird feeder, a customer needs to fill the bottle with bird seed, add the purchased accessories, and invert the bottle.

*Figure 13. Bird Feeder 1*

*Figure 14. Bird Feeder 2*

*Note: Picture taken from http://www.jjcardinal.com/feeders.htm*

*Note: Picture taken from http://www.bestnest.com/bestnest/RTProduct.asp?SKU=BCO-77401&src=pricegrabber&kilowatt=BCO-77401*
The item in Figure 13 includes a feeding mechanism for the nozzle and a hanger. As of April 10, 2007, it can be purchased at http://www.jjcardinal.com/feeders.htm for $14.95 plus shipping and handling (J. J. Cardinal’s, 2007). Figure 14 features a feeding mechanism for a soda bottle nozzle, which also serves as a stand. As of April 10, 2007, it can be purchased online for $3.99 plus shipping and handling at http://www.bestnest.com/bestnest/RTProduct.asp?SKU=BCO-77401&src=pricegrabber&kilowatt=BCO-77401 (BestNest.com, 2006). The Park could also construct their own supplies or find a different supplier. Two liters of bird seed purchased alone can cost as low as twenty-five cents to one dollar plus shipping and handling (Concord, 2007; HorseloverZ.com, 2007). However, if the Park purchased bird seed in bulk, then the cost could be lower.

We recommend that these bird feeder accessories be available in or near the nursery. This would be an appropriate area to display similar bird feeders for the customer to see in action before purchasing.

Soda Bottle Biodome

The idea behind a soda bottle biodome is to create an enclosed area that takes in sunlight, but is otherwise a closed-system. This system should also sustain life. In this way, the soda bottle mimics and provides an educational tool on the Earth’s ecosystem. This experiment generally involves soil, plant life, animal life, and water.

The basic construction of one of these ecosystems involves cutting a two liter soda bottle horizontally about one third of the height below the nozzle, filling the bottom portion of the bottle with dirt, adding a few milliliters of water to the dirt, adding physically-short plant life, adding small herbivorous animal life, and reattaching the top
of the bottle, including the cap, with adhesive. The plant life can contain as few as one to three plants and the animal life can include as few as one animal. Plant and animal life should be native to the area to ensure that they can easily survive the temperatures and amount of sunlight. See the Figure 15 below.

**Figure 15. Soda Bottle Biodome**

![Soda Bottle Biodome](http://pbskids.org/zoom/activities/sci/biodome.html)

*Note: Picture taken from http://pbskids.org/zoom/activities/sci/biodome.html.*

We recommend that the person or persons in charge of soda bottle biodomes also study other soda bottle biodome experiments and ecosystems online:

- [www.nsta.org/main/news/pdf/tst0009_48.pdf](http://www.nsta.org/main/news/pdf/tst0009_48.pdf) provides basic guidelines to making any ecosystem in a soda bottle and [http://seis.natsci.csulb.edu/rbehl/300.htm](http://seis.natsci.csulb.edu/rbehl/300.htm) provides information on ecosystems. The biodome representatives should have pre-made bottles for demonstration and knowledge of the components of these ecosystems for explanation. The representatives should explain about energy from sunlight, plants feeding animals, condensation in the bottle, oxygen gas from plants used for breathing, and other basic subject matter on the Earth’s ecosystem as shown in the bottle. We recommend that the biodome demonstrations and construction be in or near the nursery area. This would be an appropriate area to describe plant and animal life. We recommend using clear bottles for this experiment so that the children can easily see inside the biodomes.
APPENDIX F- ESTIMATION OF PARK VISITORS

In order to estimate how many people would visit the Park per day, representatives of Punto Verde followed three different methodologies. First, they split the Island into three sections. The first section was all parts of the Island that are within a twenty mile radius of the Park. The second section is all parts of the Island that are within an eighty mile radius of the Park. The last section is the entire Island. From information obtained from the census bureau, Punto Verde representatives estimated how many children resided in each of the sections. They used this information to estimate how many people from each section would visit the Park in a year. Once they reached an estimate of 300,000 patrons a year, they compared this number to already established parks. They found that the number was valid because other parks on the Island receive the same amount of people per year. Lastly, they determined how many people could fit in each area of the Park at once. They determined that the Park will be able to hold 300,000 people per year.
APPENDIX G – CONTACTS

In-Vessel Composters

Augspurger Komm Engineering
Scottsdale, AZ 85260
http://www.akeinc.com/composting.html
877 674 9336

Hot Rot Industrial Composting Systems
http://www.hotrotsystems.com/
Santa Barbara, California 93102
+001 805 884 6118

Backyard Composters

Gardener’s Supply Company
http://www.gardeners.com/on/demandware.store/Sites-Gardeners-Site/default/ViewApplication-DisplayCachedWelcomePageGardeners Supply Company
1 888 833 1412

Clean Air Gardening
http://www.cleanairgardening.com/tumbler.html
Dallas, Texas 75206
214 363 5170

Solar Power

Global Energy
www.globalenergyus.com
Murietta, California
Contact: Bryan Martin or Garrett Hoffman
951 600 1130

Green Roofing

American Hydrotech Incorporated
www.hydrotechusa.com
Chicago, Illinois 60611 – 3387
Contact: Steve Skinner
312 337 4998
Contact: Rick Clark
954 522 2775
Punto Verde Architect

Evelio Pina and Associates
San Juan, Puerto Rico 00936
Contact: Evelio Pina
787 722 0970

Biodiesel

Contractors Depot
www.cdepot.org
www.jobsitegenerators.com
Contact: Connie Carver
877 266 3532

Biofuels of Puerto Rico
San Juan, Puerto Rico
Contact: Javier Naveira
787 607 7777

Recycling

Grupo Comunitario de Reciclaje
San Juan, Pueto Rico 00741
Contact: Glorydeliz Sosa or Mariny Vásquez
787 852 9100

Solid Waste

Consolidated Waste Services Corporation
San Juan, Puerto Rico 00908
Contact: Henry Flores
787 273 7649
APPENDIX H – PHOTOVOLTAIC SOLAR GRID-TIE SYSTEM

A photovoltaic solar grid-tie system is a hybrid power system which uses locally generated solar energy to reduce energy consumption coming from an industrial grid. To connect the solar generation source to the power grid, there are a few specific pieces of equipment that are needed. Solar panels and electrical inverters are necessary to effectively use power produced by the sun. The following are product specifications on these types of components, provided to us by Global Energy, a renewable energy technology distributor based in Murrieta, California.
High-efficiency photovoltaic module using silicon nitride multicrystalline

Performance
- Rated power ($P_{mp}$): 170W
- Power tolerance: ± 9%
- Nominal voltage: 24V
- Limited Warranty: 25 years

Configuration
- SX 170B: Bronze frame with output cables and polarized Multicontact (MC) connectors
- SX 160B: Bronze frame with output cables and polarized Multicontact (MC) connectors

Electrical Characteristics

<table>
<thead>
<tr>
<th></th>
<th>SX 170B</th>
<th>SX 160B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum power ($P_{mp}$)</td>
<td>170W</td>
<td>160W</td>
</tr>
<tr>
<td>Voltage at $P_{mp}$ ($V_{mp}$)</td>
<td>35.4V</td>
<td>35.0V</td>
</tr>
<tr>
<td>Current at $P_{mp}$ ($I_{mp}$)</td>
<td>4.8A</td>
<td>4.6A</td>
</tr>
<tr>
<td>Warranted minimum $P_{max}$</td>
<td>150W</td>
<td>145W</td>
</tr>
<tr>
<td>Short-circuit current ($I_{sc}$)</td>
<td>5.0A</td>
<td>4.8A</td>
</tr>
<tr>
<td>Open-circuit voltage ($V_{oc}$)</td>
<td>43.6V</td>
<td>43.6V</td>
</tr>
<tr>
<td>Temperature coefficient of $I_{mp}$ (0.065 ± 0.015)%/°C</td>
<td>-1150 ± 20mV/°C</td>
<td></td>
</tr>
<tr>
<td>Temperature coefficient of $V_{oc}$</td>
<td>-0.49 ± 0.01%/°C</td>
<td></td>
</tr>
<tr>
<td>Temperature coefficient of power</td>
<td>649 ± 0.05%/°C</td>
<td></td>
</tr>
<tr>
<td>NOCT (Air 35°C, Sun 0.8kW/m², wind (m/s))</td>
<td>43 ± 2°C</td>
<td></td>
</tr>
<tr>
<td>Maximum series fuse rating</td>
<td>15A</td>
<td></td>
</tr>
<tr>
<td>Maximum system voltage (U.S. NEC &amp; IEC 61215 rating)</td>
<td>600V</td>
<td></td>
</tr>
</tbody>
</table>

Mechanical Characteristics

- Dimensions: Length: 1590mm (62.8"), Width: 790mm (31.1"), Depth: 50mm (1.97"
- Weight: 15.0 kg (33.1 pounds)
- Solar Cells: 72 cells (125mm x 125mm) in a 6x12 matrix connected in series
- Output Cables: RHW AWG# 12 (4mm²) cable with polarized weatherproof DC rated Multi-contact connectors; asymmetrical lengths - 1250mm (+) and 800mm (+)
- Diodes: IntegraMax™ technology includes Schottky by-pass diodes integrated into the printed circuit board bus
- Construction: Front: High-transmission 3mm (1/8" inch) tempered glass; White backsheet; Encapsulant: EVA
- Frame: Anodized aluminum alloy type 6063T6 Universal frame; Color: bronze

1. Warranty: Power output for 25 years. Freedom from defects in materials and workmanship for 5 years. See our website or your local representative for full terms of these warranties.
2. These data represent the performance of typical SX 170/160 products, and are based on measurements made in accordance with ASTM E1038 corrected to SRC (GTAC).
3. During the stabilization process that occurs during the first few months of deployment, module power may decrease by up to 1% from typical $P_{mp}$. 
Quality and Safety

Module power measurements calibrated to World Radiometric Reference through ESTI (European Solar Test Installation at Ispra, Italy); Certified to IEC 61215

UL
Listed by Underwriter's Laboratories for electrical and fire safety (Class C fire rating)

Qualification Test Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature cycling range</td>
<td>-40°C to +85°C (-40°F to 185°F)</td>
</tr>
<tr>
<td>Humidity, freeze, damp heat</td>
<td>85% RH</td>
</tr>
<tr>
<td>Static load front and back (e.g., wind)</td>
<td>50 psf (2450 kPa)</td>
</tr>
<tr>
<td>Front loading (e.g., snow)</td>
<td>113 psf (5490 kPa)</td>
</tr>
<tr>
<td>Marble impact</td>
<td>25 mm (1 inch) at 23 m/s (80 mph)</td>
</tr>
</tbody>
</table>

Dimensions in brackets are in inches. Unbracketed dimensions are in millimeters. Overall tolerances ±2 mm (1/16").

Included with each module: self-tapping grounding screws, instruction sheet, and warranty document.

Note: This publication summarizes product warranty and specifications, which are subject to change without notice.
The SW Inverter/Charger is our most popular battery based power solution for off-grid, utility backup and grid tie applications. Available in 24 and 48 volt models, it provides utility-grade output power and offers high surge capacity to run most household appliances. The SW offers many programmable features including automatic generator start and stop and automatic load sensing. Its built-in, fully automatic, three-stage battery charger is designed to bring maximum charge to batteries, while using minimum generator run time and fuel.

Features
- Available in 4000 and 5500 watt models.
- Utility grade, sine wave power.
- Durable construction for long life under extreme environmental conditions.
- Three-stage battery charging (bulk, absorption, and float) and battery equalization with remote temperature sensor for increased performance.
- Programmable control module with LCD display and LED indicators.
- Low idle current (less than 1 watt) conserves energy when no loads are present.
- Soft start capability for starting heavy loads.
- Built in starting control circuits for two and three-wire generator starting systems.

Expandable & Flexible
- Parallel stacking capability for more power at the same voltage (optional equipment is required).
- Three phase configurations available in a Power Module System for industrial quality power in remote locations (optional equipment is required) only available on 48 volt models.

Xantrex Technology Inc.
Headquarters
8999 Nelson Way
Burnaby, British Columbia
Canada V5A 4B5
604 679 8900 Toll Free
604 420 1591 Fax

www.xantrex.com

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## Electrical Specifications

<table>
<thead>
<tr>
<th>Models</th>
<th>SW404</th>
<th>SW408</th>
<th>SW554</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Input Voltage</td>
<td>120 VAC</td>
<td>120 VAC</td>
<td>120 VAC</td>
</tr>
<tr>
<td>AC Input Voltage Range</td>
<td>90-144 VAC</td>
<td>90-144 VAC</td>
<td>90-144 VAC</td>
</tr>
<tr>
<td>AC Input Current</td>
<td>60 amps AC pass through</td>
<td>60 amps AC pass through</td>
<td>60 amps AC pass through</td>
</tr>
<tr>
<td>AC Output Current</td>
<td>60 amps AC</td>
<td>60 amps AC</td>
<td>60 amps AC</td>
</tr>
<tr>
<td>Continuous Power (AC, 50 °C)</td>
<td>4000 VA</td>
<td>4000 VA</td>
<td>5500 VA</td>
</tr>
<tr>
<td>Efficiency (Peak)</td>
<td>94%</td>
<td>95%</td>
<td>94%</td>
</tr>
<tr>
<td>Output Voltage (RMS)</td>
<td>120 VAC</td>
<td>120 VAC</td>
<td>120 VAC</td>
</tr>
<tr>
<td>Output Voltage Regulation</td>
<td>± 3%</td>
<td>± 3%</td>
<td>± 3%</td>
</tr>
<tr>
<td>Frequency</td>
<td>60 Hz</td>
<td>60 Hz</td>
<td>60 Hz</td>
</tr>
<tr>
<td>Continuous Output (AC, 25 °C)</td>
<td>32 amps AC</td>
<td>32 amps AC</td>
<td>46 amps AC</td>
</tr>
<tr>
<td>Surge Capability (100 mSec)</td>
<td>78 amps AC</td>
<td>78 amps AC</td>
<td>78 amps AC</td>
</tr>
<tr>
<td>Automatic Transfer Relay</td>
<td>60 amps</td>
<td>60 amps</td>
<td>60 amps</td>
</tr>
<tr>
<td>DC Input Voltage (Nominal)</td>
<td>24 VDC</td>
<td>48 VDC</td>
<td>48 VDC</td>
</tr>
<tr>
<td>DC Input Voltage Range</td>
<td>15-33 VDC</td>
<td>42-72 VDC</td>
<td>42-72 VDC</td>
</tr>
<tr>
<td>DC Current at Rated Power</td>
<td>200 amps DC</td>
<td>100 amps DC</td>
<td>140 amps DC</td>
</tr>
<tr>
<td>Idle Consumption (Typical)</td>
<td>&lt; 1 W</td>
<td>&lt; 1 W</td>
<td>&lt; 1 W</td>
</tr>
<tr>
<td>Search Mode Consumption</td>
<td>&lt; 1 W</td>
<td>&lt; 1 W</td>
<td>&lt; 1 W</td>
</tr>
<tr>
<td>Low Battery Protection (Disabled)</td>
<td>Adjustable, low battery output and cutoff all models</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max Continuous Charge Rate</td>
<td>150 amp DC</td>
<td>60 amp DC</td>
<td>70 amp DC</td>
</tr>
<tr>
<td>Total Harmonic Distortion</td>
<td>&lt; 5%</td>
<td>&lt; 5%</td>
<td>&lt; 5%</td>
</tr>
<tr>
<td>Waveform</td>
<td>Sine wave, 3.3 x 52 cycles per cycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Sensing (Inverter Mode)</td>
<td>Adjustable, 0 to 240 watts (80 watts default)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Factor (Allowable)</td>
<td>-1 to 1 pf</td>
<td>-1 to 1 pf</td>
<td>-1 to 1 pf</td>
</tr>
</tbody>
</table>

## General Specifications

| Specified Temperature Range | 32 °F to 95 °F (0 °C to 35 °C) |
| Enclosure Type | Indoor, ventilated, steel chassis with powdercoat finish |
| Unit Weight | 155 lb (69 kg) | 165 lb (75 kg) | 176 lb (80 kg) |
| Shipping | 111 lb (50 kg) | 111 lb (50 kg) | 143 lb (65 kg) |
| Inverter Dimensions | 15.7 in x 23.5 in x 7.0 in (40 cm x 60 cm x 18 cm) |
| Shipping Dimensions | 26.5 in x 27.5 in x 15.7 in (67 cm x 69 cm x 40 cm) |
| Mounting | Wall mount |
| Warranty | 2 years |
| Part Numbers | SW404, SW408, SW554 |

## Features & Options

- Forced Air Cooling: Standard; 3-stage; speed-controlled DC fans
- 3-stage charging: Standard; 3-stage; with equalization, bulk, absorption, and float
- Control Panel: Standard: LED display, two function keys, LCD menus, and LED indicators
- Auto Generator Control System: Standard; automatic generator control system for two- and three-wire start generators
- Auxiliary Relays: Standard; three user-adjustable voltage-controlled signal relays for control of loads or charging sources
- Battery Temperature Sensor: Standard; includes remote battery temperature sensor for improved temperature accuracy
- Remote Control: SWRC - optional remote control and status indicator with standard 12V cable; optional 50' cable is available
- Stackable: SWR - optional for stackable up to 6 identical SW404s for 120V/48V output
- SWR-PR - optional for stackable up to 6 identical SW404s for 240V/48V output
- Conduit Box: SWCB - optional side conduit box for code-compliant DC wiring connections
- Grid Tie Interface: GTI - optional grid tie interface; supports utility interactive operation

## Regulatory Approvals

- CSA Listed to UL 1741 and CSA 22.2 No. 1471-95

*Note: Specifications and models subject to change without notice. This product is protected by U.S. and foreign patents and/or intellectual property rights. Copyright © 2010 Xantrex Technology Inc.
APPENDIX I – SEER DEFINITION AND PRODUCT SPECIFICATIONS

SEER is a term which stands for Seasonal Energy Efficiency Ratio. It is the standard unit of air conditioning efficiency. A SEER value is determined by averaging cooling energy in British Thermal Units to the power consumed, in Watts, by an air conditioner.
The Amana® brand ASX16 16 SEER Air Conditioner uses the environmentally friendly refrigerant R-410A and features energy efficiencies and operating sound levels that are among the best in the heating and cooling industry. R-410A is chlorine-free to help prevent damage to the ozone layer. The ASX16 features a new technology — the two-stage, high-efficiency Copeland® scroll compressor — that provides improved temperature and humidity control. The ASX16 is designed for the consumer who desires superior comfort, quiet operation, and environmentally friendly performance.

**Standard Features**
- R-410A environmentally friendly refrigerant
- Two-Stage Copeland® UltraTech Scroll compressor
- High-density foam compressor cover
- Copeland® ComfortAlert diagnostics
- High- and low-pressure switches
- Factory-installed filter dryer
- Two-speed condenser fan motor
- Copper tubing/enhanced aluminum fin coil
- Sweat connection service valves with easy access to gauge ports
- Airt Certified; ETL Listed

**Cabinet Features**
- Unique Amana® brand sound control top design
- Wire fan discharge grille
- Steel louver coil guard
- Baked-on powder paint finish
- Rust-resistant coated screws
- Compact footprint
- Top and side maintenance access
- Single-panel access to controls with space provided for field-installed accessories
- When properly anchored, meets 2001 Florida Building Code unit integrity requirements for hurricane-type winds

**Accessories**
- See list of accessories on Page 8.
### Specifications

<table>
<thead>
<tr>
<th></th>
<th>ASX16 0241A*</th>
<th>ASX16 0361A*</th>
<th>ASX16 0481A*</th>
<th>ASX16 0601A*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Cooling (BTU/h)</td>
<td>24,000</td>
<td>36,000</td>
<td>48,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Decibels</td>
<td>71</td>
<td>73</td>
<td>74</td>
<td>75</td>
</tr>
<tr>
<td>Compressor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RLA</td>
<td>10.2</td>
<td>15.6</td>
<td>21.1</td>
<td>25.6</td>
</tr>
<tr>
<td>LRA</td>
<td>52.0</td>
<td>82.0</td>
<td>96.0</td>
<td>118.0</td>
</tr>
<tr>
<td>Condenser Fan Motor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horsepower (RPM)</td>
<td>1/12</td>
<td>1/6</td>
<td>1/6</td>
<td>1/6</td>
</tr>
<tr>
<td>FLA</td>
<td>0.6</td>
<td>1.00</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Refrigeration System</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Valve Size (&quot;O.D.&quot;)</td>
<td>3/8&quot;</td>
<td>3/8&quot;</td>
<td>3/8&quot;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>Suction Valve Size (&quot;O.D.&quot;)</td>
<td>3/4&quot;</td>
<td>3/4&quot;</td>
<td>7/8&quot;</td>
<td>7/8&quot;</td>
</tr>
<tr>
<td>Valve Connection Type</td>
<td>Sweat</td>
<td>Sweat</td>
<td>Sweat</td>
<td>Sweat</td>
</tr>
<tr>
<td>Refrigerant Charge</td>
<td>140</td>
<td>160</td>
<td>205</td>
<td>200</td>
</tr>
<tr>
<td>Electrical Data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage-Hz-Phase</td>
<td>208/230-60-1</td>
<td>208/230-60-1</td>
<td>208/230-60-1</td>
<td>208/230-60-1</td>
</tr>
<tr>
<td>Min. Circuit Ampacity&lt;sup&gt;2&lt;/sup&gt;</td>
<td>13.4</td>
<td>21.8</td>
<td>27.4</td>
<td>33</td>
</tr>
<tr>
<td>Max. Overcurrent Protection&lt;sup&gt;3&lt;/sup&gt;</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Min / Max Volts</td>
<td>197/253</td>
<td>197/253</td>
<td>197/253</td>
<td>197/253</td>
</tr>
<tr>
<td>Power Supply</td>
<td>1/8&quot; or 3/4&quot;</td>
<td>1/8&quot; or 5/8&quot;</td>
<td>1/8&quot; or 3/4&quot;</td>
<td>1/8&quot; or 5/4&quot;</td>
</tr>
<tr>
<td>Ship Weight (lbs)</td>
<td>282</td>
<td>282</td>
<td>296</td>
<td>296</td>
</tr>
</tbody>
</table>

<sup>1</sup> Up to 35' in equivalent line length  
<sup>2</sup> Wire size should be determined in accordance with National Electrical Codes; extensive wire runs will require larger wire sizes  
<sup>3</sup> Must use fuses or HACR-type circuit breakers of the same size as noted

---

APPENDIX J – PARK NOISE REGULATIONS

Zone II

Area where interpersonal communication is achieved by speech, noise levels can interfere with such communication; this zone shall include any place within the property limits or that place or area within a distance of three feet from the surface of any structure, as applicable. This definition includes, but is not limited to, areas such as the following:

A. Commercial Food Establishments
   1. Restaurants
   2. Luncheon Shops
   3. Cafeterias
   4. Ice-cream Parlors
   5. Night Clubs
   6. Open-Air or Mobile Cafeterias

B. Vehicle Service Stations
   1. Gas Stations
   2. Auto Sales, and Rental Business
   3. Parking Lots
   4. Car Washes
   5. Auto Repair Services (Bodywork Shops, Painting, Mechanical Repairs)

C. Property Unlived by Humans, Miscellaneous Commercial Services
   1. Funeral Parlor
   2. Dog Pounds, Kennels and Veterinary Clinics

D. Recreation and Entertainment (Property Unlived by Humans)
   1. Theaters
   2. Stadiums
   3. Race Tracks
   4. Golf Courses
   5. Amusement and Recreation Parks
   6. Beaches, Rivers, Lakes and Lagoons
   7. Public Squares

E. Uninhabited Community Services
   1. Churches
   2. Cultural Centers
   3. Hunting and Fishing Tracts
   4. State or National Forests
ARTICLE IV  NOISE EMISSION LEVELS AMONG ZONES

4.1 Sound Level Limits

No person shall permit or cause the emission of any sound, which upon crossing the property boundaries of the sound source site shall exceed the limits set forth in Table I, as measured at or within the proper receiving zone, as these zones are defined in Article I:

<table>
<thead>
<tr>
<th>TABLE I</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOISE LEVEL LIMITS</td>
</tr>
<tr>
<td><strong>dB(A)</strong></td>
</tr>
<tr>
<td>Noise Level Exceeded 10% of the Measurement Period (L_{10})</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Receiving Zones</th>
<th>Zone I (Res.)</th>
<th>Zone II (Com.)</th>
<th>Zone III (Indus.)</th>
<th>Zone IV (Quiet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emitting Source</td>
<td>Day Time</td>
<td>Night Time</td>
<td>Day Time</td>
<td>Night Time</td>
</tr>
<tr>
<td>Zone I (Res.)</td>
<td>60</td>
<td>50</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td>Zone II (Com.)</td>
<td>55</td>
<td>50</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>Zone III (Indus.)</td>
<td>65</td>
<td>50</td>
<td>70</td>
<td>65</td>
</tr>
</tbody>
</table>

4.1.1 Correction for Background Noise (Ambient Noise)

A. If the ambient noise is less than the level set forth in the Table I by more than 5 dB(A), then the limits set forth in Table I shall apply.

B. If the ambient noise is less than the level set forth in Table I by less than 5 dB(A), then 3 dB(A) shall be added to the limits shown in Table I.

# APPENDIX K – GENERATOR SPECIFICATIONS

## DESIGN SPECIFICATIONS
- High quality, reliable and complete power unit
- Compact design
- Easy start and maintenance possibility
- All units come fully tested for load, controls and safety shutdown functions
- Fully engineered with a wide range of control options and accessories
- Warranty for 100 Biogas at EN14214 standard

<table>
<thead>
<tr>
<th>Generating Set Model</th>
<th>JS903000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Prt, kVA</td>
<td>300</td>
</tr>
<tr>
<td>Standby, kVA</td>
<td>330</td>
</tr>
</tbody>
</table>

### TECHNICAL DATA

<table>
<thead>
<tr>
<th>Engine Model</th>
<th>Scania DC12-54</th>
<th>Alternator</th>
<th>Navigane Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cylinders</td>
<td>8 inline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cubic Capacity</td>
<td>11.7 litre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compression</td>
<td>Turbocharged</td>
<td>Exhaust Temp (Max)</td>
<td>400 deg C</td>
</tr>
<tr>
<td>Engine Speed (RPM)</td>
<td>1500 rpm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>50 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amperage</td>
<td>416 amp per phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel Consumption at Full Rating</td>
<td>91.6 litres per hour</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### DIMENSIONS

| Length (A) (mm) | 4,750               |
| Width (B)       | 1,600               |
| Height (C)      | 2,045               |
| Total height of exhaust rain cap (D) | 2,445 mm |
| Max Horizontal projection of end door (E) | 1,000 mm |
| Max Horizontal projection of side doors (F) | 1,165 mm |

### WEIGHTS

| Dry (with fuel) | 4,200 kg |
| Wet (with fuel and coolant) | 4,390 kg |

### SOUND LEVELS

<table>
<thead>
<tr>
<th></th>
<th>15m, 100% loud</th>
<th>7m, 100% loud</th>
<th>1m, 100% loud</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 dB(A)</td>
<td>79 dB(A)</td>
<td>92 dB(A)</td>
<td>97 dB(A)</td>
</tr>
</tbody>
</table>

*Specifications subject to change without notice

Note. Image courtesy of JS Power Limited
From the ASTM D6751, Base 100% biodiesel must meet the following specifications before being mixed:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Test Method</th>
<th>Units</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density @ 15°C</td>
<td>ASTM D1298</td>
<td>DIN/ISO 3675</td>
<td>g/cm³</td>
<td>0.86-0.90</td>
</tr>
<tr>
<td>Viscosity @ 40°C</td>
<td>ASTM D445</td>
<td>DIN/ISO 3104</td>
<td>mm²/s</td>
<td>4.0-8.0</td>
</tr>
<tr>
<td>Flash Point</td>
<td>ASTM D93</td>
<td>DIN/ISO 22719</td>
<td>°C</td>
<td>100 min</td>
</tr>
<tr>
<td>Cold Filter Plugging - Summer</td>
<td>ASTM D4539</td>
<td>DIN EN 116</td>
<td>°C</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6 below ambient</td>
</tr>
<tr>
<td>Pour Point - Summer</td>
<td>ASTM D97</td>
<td>ISO 3018</td>
<td>°C</td>
<td>-9 max</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-20 max</td>
</tr>
<tr>
<td>Sulfur Content</td>
<td>ASTM D2622</td>
<td>ISO 8754</td>
<td>% weight</td>
<td>0.01 max</td>
</tr>
<tr>
<td>Distillation - 10% Evaporation</td>
<td>ASTM D1160</td>
<td>ISO 340</td>
<td>°C</td>
<td>To Be Determined</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>345</td>
</tr>
<tr>
<td>Carbon Residue, Conradson (CCR)</td>
<td>ASTM D189</td>
<td>DIN/ISO 10370</td>
<td>% weight</td>
<td>0.5 max</td>
</tr>
<tr>
<td>Cetane Number</td>
<td>ASTM D613</td>
<td>ISO 5165</td>
<td>45 min</td>
<td></td>
</tr>
<tr>
<td>Ash Content</td>
<td>ASTM D482</td>
<td>DIN 51575</td>
<td>mg/kg</td>
<td>0.02 max</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ISO 9245</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DIN 51777-1</td>
<td>g/m³</td>
<td>500 max</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ISO 3733</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>DIN 51419</td>
<td>DIN 51419</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Copper Corrosion</td>
<td>ASTM D130</td>
<td>DIN/ISO 2180</td>
<td>No.1</td>
<td></td>
</tr>
<tr>
<td>Oxidation Stability</td>
<td>ASTM D2274</td>
<td>IP 306 mod.</td>
<td>mg/100 mL</td>
<td>15 max</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid Value</td>
<td>ASTM D664</td>
<td>DIN 51558</td>
<td>mg NaOH/g</td>
<td>0.5 max</td>
</tr>
<tr>
<td>Methanol Content</td>
<td>GC Method</td>
<td>DIN 51608</td>
<td>% weight</td>
<td>0.2 max</td>
</tr>
<tr>
<td>Monoglycerides</td>
<td>GC Method</td>
<td>DIN 51609</td>
<td>% weight</td>
<td>0.8 max</td>
</tr>
<tr>
<td>Diglycerides</td>
<td>GC Method</td>
<td>DIN 51609</td>
<td>% weight</td>
<td>0.2 max</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>GC Method</td>
<td>DIN 51609</td>
<td>% weight</td>
<td>0.2 max</td>
</tr>
<tr>
<td>Free Glycerin</td>
<td>GC Method</td>
<td>DIN 51609</td>
<td>% weight</td>
<td>0.2 max</td>
</tr>
<tr>
<td>Total Glycerin</td>
<td>GC Method</td>
<td>DIN 51609</td>
<td>% weight</td>
<td>1.2 max</td>
</tr>
<tr>
<td>Iodine Number</td>
<td>DIN 53241 or IP 84/81</td>
<td>DIN 53241 or IP 84/81</td>
<td>cg I₂/g</td>
<td>110 max</td>
</tr>
<tr>
<td>Phosphorus Content</td>
<td>DGF C-V14</td>
<td>DIN 51440-1</td>
<td>mg/kg</td>
<td>0.2</td>
</tr>
</tbody>
</table>

We reserve the right to make changes in specifications, construction or design at any time without incurring obligation to make such changes on products sold previously.

Note. Image provided by Connie Carver of jobsitegenerators.com
SEC. 1251. NET METERING AND ADDITIONAL STANDARDS.

(a) ADOPTION OF STANDARDS.—Section 111(d) of the Public Utility Regulatory Policies Act of 1978 (16 U.S.C. 2621(d)) is amended by adding at the end the following: ‘‘(11) NET METERING.—Each electric utility shall make available upon request net metering service to any electric consumer that the electric utility serves. For purposes of this paragraph, the term ‘net metering service’ means service to an electric consumer under which electric energy generated by that electric consumer from an eligible on-site generating facility and delivered to the local distribution facilities may be used to offset electric energy provided by the electric utility to the electric consumer during the applicable billing period. ‘‘(12) FUEL SOURCES.—Each electric utility shall develop a plan to minimize dependence on 1 fuel source and to ensure that the electric energy it sells to consumers is generated using a diverse range of fuels and technologies, including renewable technologies. ‘‘(13) FOSSIL FUEL GENERATION EFFICIENCY.—Each electric utility shall develop and implement a 10-year plan to increase the efficiency of its fossil fuel generation.’’.

PUBLIC LAW 109–58—AUG. 8, 2005 119 STAT. 963

(b) COMPLIANCE.—(1) TIME LIMITATIONS.—Section 112(b) of the Public Utility Regulatory Policies Act of 1978 (16 U.S.C. 2622(b)) is amended by adding at the end the following: ‘‘(3)(A) Not later than 2 years after the enactment of this paragraph, each State regulatory authority (with respect to each electric utility for which it has ratemaking authority) and each nonregulated electric utility shall commence the consideration referred to in section 111, or set a hearing date for such consideration, with respect to each standard established by paragraphs (11) through (13) of section 111(d). ‘‘(B) Not later than 3 years after the date of the enactment of this paragraph, each State regulatory authority (with respect to each electric utility for which it has ratemaking authority), and each nonregulated electric utility, shall complete the consideration, and shall make the determination, referred to in section 111 with respect to each standard established by paragraphs (11) through (13) of section 111(d).’’.

(2) FAILURE TO COMPLY.—Section 112(c) of the Public Utility Regulatory Policies Act of 1978 (16 U.S.C. 2622(c)) is amended by adding at the end the following: ‘‘In the case of each standard established by paragraphs (11) through (13) of section 111(d), the reference contained in this subsection to the date of enactment of this Act shall be deemed to be a reference to the date of enactment of such paragraphs (11) through (13).’’.

(3) PRIOR STATE ACTIONS.—(A) IN GENERAL.—Section 112 of the Public Utility Regulatory Policies Act of 1978 (16 U.S.C. 2622) is amended by adding at the end the following: ‘‘(d) PRIOR STATE ACTIONS.—Subsections (b) and (c) of this section shall not apply to the standards established by paragraphs (11) through (13) of section 111(d) in the case of any electric utility in a State if, before the enactment of this subsection— ‘‘(1) the State has implemented for such utility the standard concerned (or a comparable standard);
“(2) the State regulatory authority for such State or relevant nonregulated electric utility has conducted a proceeding to consider implementation of the standard concerned (or a comparable standard) for such utility; or ‘‘(3) the State legislature has voted on the implementation of such standard (or a comparable standard) for such utility.’’. (B) CROSS REFERENCE.—Section 124 of such Act (16 U.S.C. 2634) is amended by adding the following at the end thereof: ‘‘In the case of each standard established by paragraphs (11) through (13) of section 111(d), the reference contained in this subsection to the date of enactment of this Act shall be deemed to be a reference to the date of enactment of such paragraphs (11) through (13).’’.

REFERENCES


H. Flores (personal communication, April 10, 2007) gave estimates on waste production


J. Naveira (personal communication, April 10, 2007) information about biodiesel for the park.


R. Clark (personal communication, April 4, 2007) gave advice on green roof installation.


Renewable energy: the viable alternative: some experts claim that in 50 years, fossil-fuel carbon emissions will need to be reduced by 60% to avert catastrophic climate change. Are we on track to achieve this?. (July 2005) In Batteries International, 40-42. Retrieved January 26, 2007, from http://find.galegroup.com/ips/infomark.do?&contentSet=IAC-Documents&type=retrieve&tabID=T003&prodId=IPS&docId=A135284264&source=gale&sreprod=ITOF&userGroupName=mlin_c_worpoly&version=1.0


Acknowledgements

• Thank you for all of your help

- Vilma Blanco
- Angélica Casanova
- Matilde Licha
- Javier Naveira
- Carolina Nevares
- Bernice Pagán
- Evelio Pina
- Angelita Rieckehoff
- Carol Rivera
- Ramón Sierra
- Beatriz Arsuaga
- Arthur Gerstenfeld
- Susan Vernon-Gerstenfeld
Our Project

• **Goal:**
  - Develop plans for waste management and propose green technology to address energy concerns in the Punto Verde Park

• **Objectives:**
  - Develop a system for waste management
  - Propose designs for energy conservation
  - Investigate renewable energy systems
Objective 1: Waste Management

Picture courtesy of Hot Rot Systems

Adapted from http://www.city.waltham.ma.us/SCHOOL/WebPage/EMS/dumpster.jpg
Objective 2: Energy Conservation

http://www.inhabitat.com/2006/08/01/chicago-green-roof-program/
Objective 3: Renewable Energy

http://www.kentenergycentre.org.uk/Renewable/Tech.asp

Picture courtesy of JS Power Limited
Objective 1: Waste Management

Waste Estimates

• Using park attendance and waste approximations
  - We estimated weekly waste production
    • \( \frac{1}{2} \) pound per person
  - We divided waste production into categories
    • 40 percent landfill waste
    • 40 percent compostable
    • 20 percent recyclable
### Objective 1: Waste Management

#### Waste Estimates

<table>
<thead>
<tr>
<th>Season</th>
<th>Weekly Park Attendance</th>
<th>Weekly Waste Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Season</td>
<td>15,000 people</td>
<td>3.75 tons</td>
</tr>
<tr>
<td>High Season</td>
<td>30,000 people</td>
<td>7.50 tons</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Season</th>
<th>Weekly Landfill Waste</th>
<th>Weekly Compost</th>
<th>Weekly Recyclable Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Season</td>
<td>1.50 tons</td>
<td>1.50 tons</td>
<td>0.75 tons</td>
</tr>
<tr>
<td>High Season</td>
<td>3.00 tons</td>
<td>3.00 tons</td>
<td>1.50 tons</td>
</tr>
</tbody>
</table>
Objective 1: Waste Management

Landfill Waste

- We recommend using Consolidated Waste Services
  - Cost is $267 per month
    - Includes dumpsters and pickup
- After the first month of operation, we recommend that Punto Verde keep track of attendance and waste production in the Park
## Objective 1: Waste Management

### In-Vessel Composting

<table>
<thead>
<tr>
<th>Model</th>
<th>Size (ft)</th>
<th>Cost</th>
<th>Capacity per Day (tons)</th>
<th>Retention Time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Rot 1206</td>
<td>23 long, 9 wide, 9 tall</td>
<td>$110,000</td>
<td>0.5</td>
<td>3-5</td>
</tr>
<tr>
<td>Hot Rot 1509</td>
<td>47 long, 19 wide, 19 tall</td>
<td>$205,000</td>
<td>1</td>
<td>5-7</td>
</tr>
</tbody>
</table>

*Picture courtesy of Hot Rot Systems*
Objective 1: Waste Management

**In-Vessel Composting**

- Our cost analysis estimated that the Park will
  - Produce approximately 156 tons of compostable waste per year
  - Pay $110,000 for an in-vessel composter
  - Use approximately $800 worth of electricity on the composter per year
  - Save approximately $3,200 per year on solid waste pickup
  - Profit approximately $1,100 per year from selling compost as fertilizer
Objective 1: Waste Management
In-Vessel Composting

Composting Net Present Value

Current Profit ($)

($30,000)  ($60,000)  ($90,000)  ($120,000)

$0  $30,000  $60,000

0  2  4  6  8  10  12  14  16  18  20

Time (Years)

Donated Composter
Invested Composter
## Objective 1: Waste Management

### Composting

<table>
<thead>
<tr>
<th>Composting Unit</th>
<th>Picture</th>
<th>Size (ft)</th>
<th>Cost</th>
<th>Capacity per Day (gallons)</th>
<th>Retention Time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Air Gardening Compost Tumbler</td>
<td><img src="http://www.cleanairgardening.com/tumbler.html" alt="Clean Air Gardening Compost Tumbler" /></td>
<td>2.7 wide, 3.7 high</td>
<td>$170</td>
<td>55</td>
<td>Varies</td>
</tr>
</tbody>
</table>
Objective 1: Waste Management

Composting

• We recommend that the Park use in-vessel composting units
  - Secure outside funding
• We recommend small scale composting units and signs as educational displays
Objective 1: Waste Management

Composting

- Educate about composting using displays
Objective 1: Waste Management

Composting

• Educate about composting using displays
Objective 1: Waste Management

**Composting**

- Increase the compostable waste by purchasing compostable products
  - Become a local supplier of the Harvest Collection from Genpak
  - Approximately $1 per plate

http://harvestcollection.genpak.com/
Objective 1: Waste Management

Recycling

- Use Grupo Comunitario de Reciclaje because they will
  - Provide bins for the Park
  - Pick up, sort, and transport recyclable goods for the Park
  - Reimburse the Park for recyclable materials
  - Create recycling programs for the Park
  - Train employees
Objective 1: Waste Management

Recycling

- Employee training
  - $25-$50 per person

- One-time educational programs
  - $3000 for reuse and recycling program
  - $1500 for kids to make crafts out of recyclable materials
Objective 1: Waste Management

Recycling

- Management of materials
  - $125 per 30 cubic yard container pickup of plastics, glass, and aluminum
  - $100 to pick up less than 20 bales of cardboard
    - Free to pick up 20 or more bales
Objective 1: Waste Management

Recycling

- Reimbursement rates

<table>
<thead>
<tr>
<th>Material</th>
<th>Return (per ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newspaper</td>
<td>$15</td>
</tr>
<tr>
<td>Cardboard</td>
<td>$25</td>
</tr>
<tr>
<td>Plastic, Glass, Aluminum Mix</td>
<td>$5</td>
</tr>
<tr>
<td>Plastic</td>
<td>$15</td>
</tr>
<tr>
<td>Aluminum</td>
<td>$600</td>
</tr>
</tbody>
</table>
Objective 1: Waste Management

Recycling Versus Composting

• We recommend that the Park use more recyclable and less compostable products because of information obtained from cost analyses
  - The use of aluminum cans instead of cups is cost effective

• Separate aluminum and plastic
Objective 1: Waste Management

Recycling

- Encourage recycling by selling toys made from recycled materials

http://www.amazon.com/Power-Rocket-Extreme-Performance-rockets/dp/B0002XHONG

http://www.jjcardinal.com/feeders.htm


http://pbskids.org/zoom/activities/sci/biodome.html
Objective 2: Energy Conservation

**Green Roofing**

- Green roofing could benefit San Juan
  - Lower air conditioning electric bills
  - Reduce the urban heat effect
  - Lower rainwater runoff
  - Clean the air
  - Clean the water
  - Provide a safe haven for birds

http://earthobservatory.nasa.gov/Study/GreenRoof/greenroof3.html
Objective 2: Energy Conservation

Green Roofing

• The ground soil cannot hold the weight of the main office building having a large scale green roof

• No roof was found to hold a small scale green roof that would be seen by many people

http://www.wildflowerturf.co.uk/Green-Roofs.html
Objective 2: Energy Conservation

Green Roofing

- We recommend that the Park create interactive signs

- We recommend investigating green roofing on new buildings or kiosks as plans develop
Objective 3: Renewable Energy

Solar Energy In Puerto Rico

• The power company does not approve of local energy sources being supplemented by their power
• By April 2008, the power company is scheduled to approve a net metering system on the Island
Objective 3: Renewable Energy

Photovoltaic Solar Energy

- The average cost of a Photovoltaic Solar Panel System is approximately $7 per watt
  - If an $840 system is in the sun for $\frac{1}{2}$ day, then it could power a 120 watt light bulb for the other $\frac{1}{2}$ day

http://www.kentenergycentre.org.uk/Renewable/Tech.asp
Objective 3: Renewable Energy

Photovoltaic Solar Energy

- Global Energy is willing to sell equipment for $5 per watt
  - The Park can purchase a 10 kilowatt system for $52,000
  - The panels would occupy 816 square feet of the 2,500 square foot roof

http://www.kentenergycentre.org.uk/Renewable/Tech.asp
Objective 3: Renewable Energy

Photovoltaic Solar Energy

- Our cost analysis estimated that
  - The Park will purchase a 10 kilowatt system for $52,000
  - The Power Company charges $0.17 per kilowatt
  - The Park saves between $3,000 and $8,000 per year on electricity costs
- Depending on the sunlight collection hours
Objective 3: Renewable Energy
Photovoltaic Solar Energy

Solar Power - Net Present Value

<table>
<thead>
<tr>
<th>Current Profit ($)</th>
<th>Time (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>($60,000)</td>
<td>0</td>
</tr>
<tr>
<td>($50,000)</td>
<td>2</td>
</tr>
<tr>
<td>($40,000)</td>
<td>4</td>
</tr>
<tr>
<td>($30,000)</td>
<td>6</td>
</tr>
<tr>
<td>($20,000)</td>
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</tr>
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<tr>
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<td>$50,000</td>
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<tr>
<td>$60,000</td>
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</table>

5 Hour Worst Case Scenario
8 Hour Feasible Scenario
10 Hour Best Case Scenario
Objective 3: Renewable Energy

Photovoltaic Solar Energy

- We recommend that Punto Verde use a solar system as outlined in our analysis
  - Do not use entire solar light pole and bollard budget
  - Install a grid-tie system after net metering legislation is passed
- We recommend that Punto Verde educate visitors about solar technology
Objective 3: Renewable Energy

Biodiesel

- A biodiesel generator can power the entire Park
- A biodiesel generator can be purchased from JS Power Limited

Picture courtesy of JS Power Limited
Objective 3: Renewable Energy

Biodiesel

• Biodiesel generator emissions are
  - Environmentally better than petroleum fuel emissions
  - Not as environmentally friendly as solar power
Objective 3: Renewable Energy

**Biodiesel**

- Existing company Biodiesel of Puerto Rico can provide fuel
  - Switch to Biofuels of Puerto Rico if it becomes a less expensive option
- **Our cost analysis indicates that biodiesel is the least expensive option to power the Park**
Objective 3: Renewable Energy

Biodiesel

• Our cost analysis estimated that
  - The Park needs 175 kilowatts to operate
  - The Park will use energy 300 hours a month
  - The annual electricity charge from the power company will be approximately $107,000
  - The annual cost of fuel will be approximately $99,000 if purchased from Biodiesel of PR
  - A generator will cost approximately $49,000
Objective 3: Renewable Energy

Biodiesel

Biodiesel Net Present Value

<table>
<thead>
<tr>
<th>Net Present Value ($)</th>
<th>0</th>
<th>10,000</th>
<th>20,000</th>
<th>30,000</th>
<th>40,000</th>
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<tr>
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<td>10,000</td>
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</tbody>
</table>

Time (Years)

Current Profit ($)
Objective 3: Renewable Energy

**Biodiesel**

- We recommend purchasing a biodiesel generator if the Park
  - Gets a commitment of 5,000 gallons of fuel per month from Biodiesel of Puerto Rico
  - At a price $0.61 per liter

- Keep up to date on Biofuels of Puerto Rico
  - Potentially less expensive fuel
Recommendations

Questions?

Green Roofing

Regular Roofing