The Potential for a Micro-Hydroelectric System at the FCRE
Evaluating Environmental, Social, and Financial Costs of Energy Use

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ABSTRACT

The electricity that is consumed at Pitzer’s Firestone Center is expensive and its production results in negative social and environmental consequences. Through my research, I have found that a micro-hydroelectric system at the Firestone Center could reduce these environmental and social impacts and potentially eliminate the financial costs to Pitzer of its electricity use. By reading articles, examining past electrical bills, speaking with ICE (the local electric company) as well as current owners and vendors of micro-hydro systems, and taking hands-on measurements at the property, I have thoroughly evaluated the potential for a micro-hydro system at the Firestone Center and the benefits that it could bring. In this paper, I detail the environmental, social, and financial issues associated with the Firestone Center’s current electricity use. I provide an overview of micro-hydroelectricity and then discuss it with regards to its potential at the Firestone Center. Finally, I look at environmental, social, and financial concerns with respect to a potential micro-hydro system. I conclude that the Firestone Center would most likely be better off in all three of these areas of concern if it were to follow through with the install of such a system.

INTRODUCTION

Eighteen percent of the world’s electricity is currently generated from “clean” renewable sources (REN21, 2010). Thanks to an impressive environmental conscience and fortunate resources, 99% of electricity consumed in Costa Rica is produced renewably (Justin, 2008). In comparison to the world as a whole, next to no CO₂ is emitted in Costa Rica directly for the purpose of generating electricity. This is great, especially considering the ever-growing threat of climate change to our planet and an ensuing global energy crisis.
However, Costa Rica’s electricity production (and thus, consumption) is not void of environmental and social harm.

Much like the country in which it is situated, Pitzer College’s Firestone Center for Restoration Ecology (FCRE) in Barú, Pérez Zeledón, Costa Rica is gifted with natural resources and managed with keen environmental and social consciences. The Firestone Center could produce its own electricity if a micro-hydroelectric generation system were installed. This could reduce and potentially eliminate negative impacts the Firestone Center currently has on the environment, people, and ultimately, Pitzer’s budget.

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS OF CURRENT ELECTRICITY CONSUMPTION AT THE FCRE

Methods of producing electricity that are considered to be “clean” and “renewable” tend to be considered so because they do not burn fossil fuels to produce electricity. Four of the most common forms of clean energy are solar, wind, hydro, and geothermal. While these “clean” forms of energy production tend to be significantly less environmentally harmful than their CO₂-emitting counterparts, the environment still takes a hit from their presence.

A critical eye will note that the construction of any power source hurts the environment to some extent, even if the source’s actual process of generating electricity is environmentally benign and its energy resources limitless. Materials must be made, installation sites must be cleared, parts must be transported, and certain parts must ultimately be disposed of. Any maintenance that is later required delivers similar costs on the environment. In some cases of solar and wind power plants, the environmental harm stops here. With large-scale hydro and geothermal electricity projects however, there are often significant environmental effects from running the power plant. A geothermal plant that emits water vapor that would otherwise be trapped
underground arguably contributes as much to climate change as a coal-fire plant of the same size. Water vapor is a greenhouse gas like CO₂. Certain geothermal plants avoid water vapor emissions through a “closed-loop” system in which liquids and gasses drawn from the ground are replaced into the ground instead of being released into the atmosphere. Hydropower plants can disturb aquatic ecosystems both up and downstream and can flood important lands surrounding rivers: forcing species to struggle and people to move (Brower, 1992).

Most of Costa Rica’s electricity comes from hydroelectric and geothermal plants. About 80% comes from large-scale hydro projects, and an additional 10%+ comes from geothermal sites (Mills, 2010). While its contrast to the electrical production in other countries may make Costa Rica’s electrical production appear benign, this is not the reality. Most of the electricity that arrives at Pitzer’s Firestone Center in Barú comes from the Cachi hydroelectric plant in the province of Cartago (ICE Interview, 2010). The Cachi plant has a dam with a reservoir on the Reventazón River. The system was constructed in the sixties. There was river expansion in the mid-seventies that allowed for Cachi to increase its power output to the present-day level of over one hundred megawatts (2010, “Plantas”). While I was able to find little information available about specific environmental damages caused by Cachi’s construction, expansion, and current operation, it is safe to assume that they are consistent with the damages caused by most hydroelectric electric dams as mentioned earlier.

When electricity demand is high in the area of the Firestone Center, extra electricity comes from the larger Arenal hydroelectric project in Guanacaste (ICE Interview, 2010). The construction of this power plant was more than just environmentally harmful; it required communities to be relocated (2010, “Plantas”). When the area of the Firestone Center reaches peak electricity
demand, diesel generators are used to produce the necessary extra energy (ICE Interview, 2010). Needless to say, these diesel generators, with their CO₂ emissions, loud noise, and consumption of fuel are not particularly kind to the environment.

Despite the plethora of backup power supplies, frequent power outages burden the Firestone Center and the rest of southwestern Costa Rica. Among other purposes, the Diquís hydroelectric project, due for completion in 2016, seeks to provide more consistent power to the area (Aguero, 2010). The proposed project will dam the General River, creating a six million acre reservoir. The result will be the ability to produce up to 630 megawatts of renewable power. This will make electricity more consistent for more people over a wider area and allow for economic expansion (Tigre, 2010). However, the list of negative environmental and social impacts of this hydroelectric project looks as though it will be particularly long. If the project is completed as expected, it will provide electricity to the Firestone Center in the future. Thus, the project’s environmental and social impacts should be of considerable concern to Pitzer.

There are 21 kilometers of river downstream from the proposed Diquís dam site. This stretch houses the most important collection of mangroves in the country. The dam will block 90% of the water flow on this stretch of the river, preventing the river and its shores from remaining ecologically sound. With only a tenth of the water, the wetlands will dry, potentially resulting in the extinction of species: harming the biodiversity that plays a substantial role in the country’s appeal to tourists (an appeal that has made tourism a leading industry that is critical to the Costa Rican economy) (Moscovici and Wegner, 2009).

Too much water is no ecologically healthier than too little. To form the project’s giant reservoir the land that it will cover must be flooded. Not only will this destroy lands that are currently not submerged, it will create a body of
still water that does not occur naturally in the area. Species that are accustomed to living in the flowing water of the river will struggle in the stagnant lake that will be created. Species have been lost due to similar circumstances in the past (Moscovici and Wegner, 2009).

It is not just the wildlife that should fear the construction of the Diquís dam. As seasons change, water levels downstream and at the reservoir will fluctuate. Earth that is saturated during the rainy season will dry with less rainfall. The characteristic winds of the region will create dusts that could burden surrounding populations including the 48,000-person city of Buenos Aires that is only 13 kilometers from the reservoir site (Moscovici and Wegner, 2009)(Oviedo, 2010). Smaller, closer towns have more than dust to worry about. Eight small, relatively poor towns will be flooded by the reservoir. 1,068 people will be displaced from their homes. ICE, Costa Rica’s electricity and communications company that is behind the Diquís project, will compensate those who are forced to leave their homes. But regardless of compensation, forcing people away from their homes is no socially benign task. Also, some lands that will be flooded by the reservoir are owned and inhabited by indigenous people. These lands, which the indigenous people have been accustomed to living on for thousands of years, are arguably even harder to replace through compensation than the lands of the small towns that will be flooded (Moscovici and Wegner, 2009).

**FINANCIAL CONSIDERATIONS OF CURRENT ELECTRICITY CONSUMPTION AT THE FCRE**

Pitzer’s Firestone Center currently gets its electricity through the local power grid from ICE. I was able to get a hold of some electrical bills from previous years at the Firestone Center and calculate average electricity consumption and costs. I treated the electrical consumption of the entire
property as a whole (the ecology center, the program house, and the home of the property’s supervisor, Greddy, combined). It should be noted that the billing of electricity is split, and that a micro-hydroelectric system could power a specific section of the Firestone Center as opposed to the whole property if this were desirable for any reason. Prices that ICE charges per kilowatt-hour (kWh) vary based upon time of day, amount of electricity being used, etc (2010, Tarifario). There is also a five percent government tax on electricity (ICE Interview, 2010). Despite fluorescent lightbulbs, no air conditioning, and an emphasis on outdoor activity, the whole of Pitzer’s Firestone Center consumes roughly 610 kWh per month. Since the beginning of 2008, this has cost Pitzer about 60,000 local Colones or $120.00 U.S. dollars per month after taxes. This equates to nearly $1,500 a year just to power the already-energy-conscious Firestone Center. This, considered alongside past, present, and potential future environmental and social effects of the Firestone Center’s electrical consumption, begs the question of if there may be a better way to power the property.

**MICRO-HYDROELECTRICITY**

Hydroelectricity is the process of converting the power of flowing water into electrical energy. Water is harvested from a flowing source such as a stream or river and causes a turbine to spin. This spinning turbine drives a generator that creates an electrical current by spinning a magnet relative to a wire coil. “Micro-hydroelectricity” simply refers to small-scale hydroelectric systems. As opposed to a system that dams an entire river and powers whole communities like the Cachi, Arenal, or Diquis projects, a micro-hydro system takes a portion of water from a relatively small creek or stream to fulfill modest electrical demands (New, 2004).
A typical micro-hydroelectric setup consists of a water source, a pipe, and a powerhouse. Water enters a pipe through an intake in a creek or stream. An intake is at the open end of the pipe that is highest in elevation. An intake is best placed in a deep area of the water source to prevent air from entering the pipe. Air can reduce the power output of a system or even damage the turbine. It is also smart for an intake to have some sort of screen to prevent debris from entering and clogging the pipe. The pipe or “penstock” is used to concentrate the water as it flows downhill to build up pressure. Water that flows freely downhill with the stream is able to dissipate and loses energy. Wider (larger diameter) pipes are more efficient because they create less friction against the water. However, they are also more expensive (New, 2004).

I expect that a system installed at the Firestone Center would use a Pelton wheel turbine. For this design, the lower end of the pipe closes off into a small opening (nozzle) or multiple nozzles. The nozzle pressurizes the water further, maximizing the energy with which the water hits the turbine. The turbine itself has little to separate it from an old-fashioned waterwheel except that it is made with durable materials and its “blades” are in the shapes of cups that are designed for optimal efficiency (See Figure 1). A strong jet of water comes out of the nozzle and hits the blades of the turbine, causing it to spin. A Pelton wheel turbine is classified as an impulse turbine because of the brief force (impulse) that a water spray exerts on each of the turbine’s blades to power it. Other turbines function while fully submerged underwater. A Pelton turbine transfers its rotational force to the generator either through a direct shaft connection or a gearing system that typically involves a chain or rubber belt. The generator sends electricity to appliances, storage batteries, resistance heaters to consume excess electricity, or if connected, to the local power grid. A powerhouse is simply a covering for the turbine and generator to protect them.
from the elements, though the term is also used in reference to the turbine and generator discussed as a single unit (New, 2004).

Water gets its power from two important characteristics: head and flow. Head is the vertical distance that water drops (for micro-hydro purposes, from an intake to a turbine). The gravitational force on the water over this distance creates pressure that powers the turbine. Head can be measured directly as height, in feet or meters for example, or as pressure at the lower end of a pipe. Pressure is often measured in pounds per square inch (PSI). Flow is the sheer amount of water that is “flowing” to the turbine. In a Pelton wheel setup like I foresee at the Firestone Center, there is almost always more flow available from the stream than is actually utilized by the system. Not all of the available water is diverted to the turbine (New, 2004). From an environmental standpoint this is a good thing, as species still have water with which to live and no flooding occurs. The usable flow is essentially the volume per unit time of water that is able to enter the intake. This is usually measured in liters per minute (LPM) or gallons per minute (GPM). Presented simply, more water dropping more vertical distance equates to more available “waterpower” that can be turned into electricity.

MICRO-HYDRO AT THE FCRE

The Firestone Center is about as ideal of a location as exists for a micro-hydroelectric system. The property is steep, with an elevation drop of over 340 meters (1,115 ft) across its 145-acre property (“Firestone”). Conveniently, the three buildings that account for all of the electricity consumption on the site are situated at the bottom of the property. There are also three substantial flowing water bodies that cover most of the elevation drop of the FCRE: the South Creek, the Terceopelo Creek and the North Creek (which feeds into the larger
Quebrada Cacao that passes by the ecology center) (McFarlane et. al., 2009).

Also, I discovered early on that micro-hydro was a true possibility in the area of the Firestone Center. Two of the locations that my peers and I visited during study trips with our past classes had micro-hydro systems installed.

Knowing that the basics appeared very promising for a micro-hydroelectric system at the Firestone Center, I started to look into the specifics: How much electricity could actually be produced on the property? How much would it cost to install, run, and maintain a system? How much money could Pitzer save or even earn by investing in such a project? What new environmental and social impacts might a micro-hydro system at the FCRE have? Unfortunately, it is next to impossible to get fully accurate answers to these questions prior to actually going ahead and installing and running a system. There is so much variance in the sizes of turbines and generators that might be used, the locations for potential intakes and powerhouses, the diameters of piping, the flow of streams based upon weather and season, and the charges that different companies will bill for their products and services as pertaining to the specific site. However, I have been able to come up with ballpark estimates of figures and educated suggestions as to how Pitzer and its installer might proceed.

Based upon my readings, I set out to try to evaluate the reality of a minimal micro-hydroelectric system that might be installed at the Firestone Center. To do this required three main steps: selecting locations for an intake and a powerhouse, calculating flow, and calculating head. I chose to use the Terceopelo Creek that passes through the center of the property and whose banks are reasonably accessible from outside the ecology center. I chose a flat, open clearing near the road in front of the ecology center as my proposed powerhouse site. This space is next to Terceopelo creek just before it passes
through a tunnel under a driveway to connect with Quebrada Cacao (See Figures 2-4). This location is about as low as one can get on the property, maximizing the potential waterpower that could reach it. It is also easily accessible (even by vehicle), and is far enough away from the typical locations of both human and animal users of the Firestone Center to ensure that no one would be bothered by any noise that a turbine might produce. To select my intake location, I hiked up along the Terceopelo Creek until I found a place that concentrated the water and was well above my proposed powerhouse site (See Figures 5 & 6). An intake could certainly be installed much higher than this site to provide much more head, but I was estimating for something minimal. With the abundance of potential head and flow throughout the Firestone Center property, the sky is practically the limit in terms of the scale of micro-hydro setups that could be done. Logically, the catch is that larger setups typically come with higher price tags (2010, Hydroelectric).

I was able to find some flow data for Terceopelo Creek that had been recorded by a previous student, Benjamin Milam, in the summer of 2008. After interpreting and converting his data, I came up with some numbers from his work that were useful for my interests. He calculated flow before, during, and after an episode of heavy rain. He used the velocity-area method for his calculations. This method entails measuring the area (height X width) of a cross-section of the water in a creek and measuring the velocity at which water passes this cross-section. Water velocity was measured using a flow meter (Milam, 2008). My interpretations and conversions of Benjamin’s data resulted in figures of 600-3,600 liters per minute or about 160-950 gallons per minute. This enormous range represents the difference between typical creek flow and

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1 Benjamin’s data seemed to have been labeled wrong in his paper. This was confirmed by professor Cheryl Bauduini who originally referenced me to his work.
flow after heavy rain. To confirm my findings from Benjamin’s data, I used a different method to approximate the flow of Terceopelo Creek adapted from New’s “container fill method” (2004). I made a jug that I measured to hold 5.4 liters, and found a place along Terceopelo Creek where rocks concentrated all of the stream’s flow into two spouts. I timed how long it took for me to fill up the container with each spout, using several trials for each (See Figure 7). It was impossible to fill the container completely to its rim, because it had to be slightly angled. To account for this, I removed the extra 400 milliliters from the measurement and considered a “full” jug to be a clean five liters. One spout consistently filled the jug in two seconds. The other spout consistently filled it in one second. Adding these data from the two spouts returned the total flow for the creek: about 7.5 liters per second or about 450 LPM. This value is similar to those at the bottom end of Benjamin’s data. This is makes sense, because I did my test many hours after any rain had fallen.

I measured head by again working off of ideas that were mentioned in New’s piece so that they fit my liking and could be accomplished using tools that were available to me. Starting at my proposed intake site, I measured the vertical distance down to my proposed powerhouse site using a two-meter stick and a balance. I stood up straight at the intake site and held the two-meter stick horizontally to the ground at eye height, pointing at the trunk of a tree that stood on lower ground closer to my powerhouse site. I placed the balance on top of the two-meter stick to ensure that I was holding it at a perfect horizontal angle. I noted the point on the tree trunk that was directly across from my eye level, walked to the base of the tree, and then used the two-meter stick to measure the height from the ground to the noted point on the tree trunk. I subtracted my eye height from this measurement to get the vertical drop from my intake site the ground at the base of the tree (See Figure 8).
As I traveled down the hill, the terrain became less rugged and I was able to start taking good measurements every two horizontal meters. Instead of holding the two-meter stick to my eyes and having to subtract eye height, I simply measured from the ground to directly find the height difference between the ground I was on and the ground two meters horizontally closer to my powerhouse site. To do this, I held one end of the two-meter stick on the ground of where my last measurement was made, and noted where the other end touched on a downhill plant or rock. Again, I used the balance on the two-meter stick to ensure that I was holding it at a perfect horizontal. I then went to the downhill plant or rock and measured the distance from the noted point on it to the ground.

Using these methods, I measured the vertical distance all the way down to my proposed powerhouse site. After adding my measurements, I came up with a head of 560 centimeters or 5.6 meters. I also used the two-meter stick to measure the potential path of a pipe for the system and found that about 86 meters of pipe would be necessary to stretch from the intake to the turbine.

The setup for which I measured is small compared to the scale of what is possible at the Firestone Center. However, it would still be capable of producing some usable electricity. With an efficient and versatile turbine, the setup that I measured should be able to maintain about 100 watts of output and peak (with heavy rain) at as many as 1,500 watts (1.5 kW) ("How"). While this may not be enough to power the whole Firestone Center, it could, for example, offset the demands of the 220-watt air dehydrator in the dry room of the ecology center. The dehydrator runs 24/7 and skyrocket the Firestone Center’s electrical bill.

I am glad that I was able to get the hands-on experiences of measuring head and flow, and that I was able to produce some useful numbers in case Pitzer wishes to start with or can only afford to invest in a small-scale micro-
hydro system. However, my first recommendation would be to utilize the full potential of the property to generate as much electricity as the FCRE uses, or even more: a process that would carry the FCRE away from the negative environmental, social, and financial effects of its current means of obtaining electricity. To learn more about this possibility, I have been in touch with David Waters, a San Isidro consultant for the company Solar Costa Rica, who works with micro-hydro systems and lives just outside Tinamastes (a fifteen-minute drive from the Firestone Center). To accurately evaluate an install, he would have to visit the Firestone Center and perform a proper estimate. However, through chatting and exchanging figures over the phone we were able to come up with some ballpark estimates of what a larger micro-hydroelectric system at the FCRE could entail.

Terceopelo Creek and North Creek both fall some 300 meters (984 ft) to the base of the Firestone Center property. The South Creek that passes near to the program and supervisor houses falls nearly 200 meters (656 ft) (“Firestone”). So, ample head is available from multiple flowing water sources on the property. David and I figured (me being familiar with the site and him being familiar with his pricing and available equipment) that Pitzer could install one or two of his 900 to 1,000 watt systems with Pelton wheel turbines. According to David, one of these systems would require only 200 feet (61 m) of head. If, as I anticipate, Terceopelo Creek were used, most of the creek on the property would be above the intake, leaving more space for water to be collected prior to the intake, and thus allowing for greater flow at the intake. David predicts that installing one such system (parts and labor) would cost somewhere in the range of $6,000 U.S. dollars (3,000,000 local Colones). Considering that Pitzer will otherwise pay this much in electricity bills for the Firestone Center over the next four years, and that one of these systems alone
could fulfill almost all of the Firestone Center’s electrical needs, at face value it sounds like quite an inviting investment. Assuming that electrical consumption and costs remain consistent with the FCRE’s ICE bills that I reviewed, this hypothetical system would pay for itself in five years while substantially reducing the FCRE’s contributions to the environmental and social problems discussed earlier.

If two of the 0.9 - 1 kW Pelton wheel systems were installed, the Firestone Center would produce considerably more electricity than it consumes. To install twice the system may cost twice as much up front, but it would not necessarily double the time it would take for the system to pay for itself and start saving Pitzer money. Since the Firestone Center is already connected to the public power grid, it could sell excess electricity back to ICE, the power company. When I interviewed a representative from ICE, he told me that they would pay the same amount per kWh to purchase electricity that they charge to sell it (before taxes). Again, this amount fluctuates based upon a number of factors, but if I look at the FCRE’s bills, subtract the taxes, and average the numbers, it looks as though ICE would pay an average about 19 U.S. cents or 95 local Colones per kWh produced at the FCRE. With two of David’s generators, the Firestone Center could likely produce hundreds of extra kilowatt-hours per month to sell back to the grid. This translates to many hundreds of U.S. dollars earned by Pitzer per year from the prospective sales of the FCRE’s electricity. By not only saving money that Pitzer would otherwise be spending on electrical bills, but also creating a new source of income, a larger micro-hydro setup at the FCRE could pay for itself at a faster rate and be a more profitable investment for Pitzer in the long run.

David and his company are not the only ones who could install a micro-hydro system at the Firestone Center. There are other companies in Costa Rica
that install, and turbines and generators of all types are available from companies around the world. Also, Harvey Mudd College’s engineering clinic program is often looking for projects, and according to Professor Paul Steinberg as well as my personal experience in an HMC engineering class; it has expressed interest in on-site energy production at the FCRE. This option would likely entail Harvey Mudd students coming to the Firestone Center to install a system. According to David, other companies will only install their own equipment so that they can ensure that it will work. It may be more economical for the Firestone Center to install just one larger system as opposed to two of David’s smaller ones. Harvey Mudd or another company may be able to provide this. A local farmer on one of the properties that I visited had a 1.5 kW Pelton wheel generation system, one perfectly-sized for the FCRE. He said that he spent only 400,000 Colones (§800 USD) on his system. This is because all on which he spent money was parts, and he bought a used turbine and generator. His children installed the system. This is evidence that, with a little elbow grease, a system that could power the entire FCRE and more could be possible for a price equivalent to just months of electricity bills. If Harvey Mudd takes on the task, a system could come at virtually no cost to Pitzer whatsoever, as HMC already have money set aside for their clinic projects. Figure 9 in the appendix has useful contact information for considering an install.

CONCERNS SURROUNDING MICRO-HYDRO AT THE FCRE

There are valid points of concern surrounding the implementation of a micro-hydroelectric system at the Firestone Center. However, nearly all of them seem minimal in comparison to the concerns surrounding the Firestone Center’s current electricity use. An obvious concern is that spending six or even twelve thousand U.S. dollars (if necessary) to install a powerful and reliable micro-
hydro system at the FCRE is no small upfront cost. However as discussed earlier, overtime a system is essentially guaranteed to be a positive financial decision. Pitzer may even be able to advertise the move to boost its environmentally conscious image. It should again be noted that the numbers I have presented are rough. To get a more accurate assessment of power output and cost, professionals who know their equipment and pricing should carry out an estimate at the FCRE. David Waters told me that since he lives so close, he might be able to do an estimate when he has time for as little as 20,000 to 25,000 Colones (§40 - §50 USD).

The Representative from ICE with whom I spoke told me that ICE would buy back electricity at their sales rates. However, David was skeptical of this. He says that other workers from his company have had recent meetings with ICE, and have discovered that selling electricity from private property may not be as easy as ICE makes it sound. David reassured that the Firestone Center could probably expect to zero-out their electricity bill, but he said that it should not count on being able to profit beyond that. The two properties with micro-hydro systems that I visited were both off grid, so I could not learn more about the reality of selling to ICE from them. Whether ICE pays for it or not, excess electricity from the Firestone Center would be sent onto the grid, so the public could also benefit from the more socially and environmentally responsible energy production.

What I consider to be the biggest concern for micro-hydro at the FCRE is the dry season. A turbine has to be fed by a creek, and a creek has to be fed by rain. The Quebrada Cacao flows year round, but according to professor Cheryl Bauduini, sometimes the flows of the creeks on the property are greatly reduced during the dry season. This is substantial, and definitely something that should be considered when installing a micro-hydro system. However, it may be
possible to place an intake in the Quebrada Cacao as opposed to Terceopelo or North Creek. Regardless, a turbine on one of the creeks would still run most of the year and greatly reduce the electricity costs (financial, social, and environmental) at the Firestone Center.

The required maintenance of micro-hydroelectric systems is minimal. I learned this with confidence by talking to the same owner of the 1.5 kW Pelton wheel setup. He said that the only maintenance that he’s had to perform over his eight years of owning the system have been replacing the drive belt every three years and the occasional lubrication. And his turbine and generator had been installed and running in another location for any number of years prior to his acquisition of them! The property supervisor or even the students could perform this very occasional and simple maintenance.

Environmental and social concerns surrounding a micro-hydroelectric system at the Firestone Center are few. As with any new purchase, the energy that goes into assembling and transporting parts may not be environmentally and socially benign. Possible direct effects on the environment would be negligible in the face of something like the Diquís project. Flow would be reduced in the creek between the intake and the powerhouse, but only during this small stretch. This should have minimum effects on the wildlife at the Firestone Center that is already accustomed to changing flow rates as a result of rains. Workers treading over plants during installation and pipes displacing any life forms through their use of space are the only other environmental effects worth noting that have come to attention (Harper, 2010). The aesthetics of the pipes, the powerhouse, and any new wires that need to be placed could potentially be displeasing to users of the Firestone Center. Also, the turbine would likely make some noise, however it is unlikely that anyone would be disturbed by it. Assuming my proposed powerhouse location is used, the turbine
would be far away from students, staff, and residents alike, and feet away from the road on which loud engine-braking trucks routinely pass anyway.

CONCLUSION

Pitzer should seriously consider installing a micro-hydroelectric system at its Firestone Center. After a month of research, I expect with confidence that such a system would be a positive financial investment and would reduce Pitzer’s contributions to environmental and social problems in Costa Rica. Energy generated on site, no matter how much or how little, is energy that does not need to be purchased from the power company, and is thus money saved. Also, the less electricity the Firestone Center draws from ICE, the less it is supporting the harm done by current power plants and the less it is encouraging the company to follow through with an unwholesome project like that at Diquís. If future students at the Firestone Center are interested in assisting Pitzer with the process of actually selecting and installing a micro-hydro system, I hope that I have laid solid groundwork from which to progress. Regardless, I hope that my efforts and findings will inspire decision-makers at Pitzer to look into micro-hydroelectricity with excitement, optimism, and a desire to use resources with which the Firestone Center is gifted to Pitzer and Costa Rica’s advantage.
APPENDIX

Figure 1

Figure 3

Josh Cohen, 2010
Figure 4

Ecology Center

Proposed Powerhouse Site

Teresopolis Creek

Josh Cohen, 2010
Figure 5  (Photo taken from bridge to ecology center.)
Figure 6 (Photo taken closer to proposed intake site.)

Josh Cohen, 2010
Figure 7

Lindon Pronto, 2010
Figure 8

Josh Cohen, 2010
Useful Contacts for Investigating a Micro-Hydro Install at the FCRE:

David Waters  
San Isidro consultant for Solar Costa Rica  
Also affiliated with PowerSpout: a micro-hydro company out of New Zealand.  
Lives 15 min from FCRE  
(506) 8869-3470

Solar Costa Rica  
Solarcostarica.com  
2582-0623 (from Costa Rica)  
305-454-4447 (from U.S.)  
*Note: As the name suggests, they do mostly solar setups. It is important to be clear about looking for a micro-hydroelectric system.

Roberto Kopper  
San Jose, Costa Rica  
Experience with micro-hydroelectricity and selling power back to the grid.  
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REFERENCES


