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Sustainable Fitness Centers

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Abstract

The world is in the midst of an energy crisis and it is only going to get worse. World energy consumption rates are increasing by the day; meanwhile, the amount of available natural resources to generate energy is decreasing at impressive rates. In addition, humans are becoming more aware and educated about the vast impact that their daily lives have on the environment. Scientists have discovered that the earth has been gradually warming over the past few decades. Natural cycles within the earth's climate, at this time, cannot fully explain the relatively large increases in surface temperature in such a short amount of time. Therefore, the United States and the rest of the world are changing their attitude toward the environment. Instead of a use and abuse policy that we once had as humans, we are changing into a reuse, recycle, and renew society.

In an attempt to incorporate sustainability within the daily lives of humans, as a solution to the energy and global warming crises, I have developed a prototype for a system that coverts kinetic energy or "human energy" to useful electrical energy. The prototype produces clean, renewable energy by harnessing the energy spent by a gym user on an upright exercise bicycle. The electrical energy will then be incorporated into the gym's electrical grid and used immediately to power low voltage circuitry such as televisions, fans and lights within a closed loop system.

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Capstone Project Body

Americans need to change their attitude toward the environment. Instead of continuing the "use and abuse" policy that we currently exercise, Americans need to change into a reuse, recycle, and renew society. Americans should no longer be willing to purchase goods or services unless they are created using environmentally conscious practices and materials. Currently the United States uses 9.3% of the world's energy, and consumes more energy per person than any other country in the world (Energy Statistics). Simply stated, the United States is in the middle of an energy crisis. James Canton, a renowned global futurist and social scientist has predicted that "Fueling the Future," must become the nation's chief priority for the future. Canton explains, "We are running out of energy. New global demands from every nation will outpace supply within twenty-five years unless plentiful new sources are found."

To further exacerbate the energy crisis, scientists have discovered that the Earth has been gradually warming over the past few decades. Natural cycles within the Earth's climate, at this time, cannot fully explain the relatively large increases in surface temperature of the Earth in such a short amount of time. Therefore, something else must be occurring within the atmosphere to cause such a dramatic increase in Earth's surface temperatures. It has become apparent that humans are most likely the cause of the increased temperatures, because human activity has increased the amount of greenhouse gasses within the Earth's atmosphere. Greenhouse gasses are directly attributed to the burning or combustion of fossil fuels. Currently the United States of America gets most of

its energy from energy plants that burn fossil fuels such as coal and oil. However, everyday activities such as driving a car or plugging in a hair dryer also increase the amount of greenhouse gases.

Americans can no longer ignore the vast impact they are having on the environment caused by their unsustainable living habits. This type of living has rendered the Earth's fossil fuel reserves inadequate for the future. In addition, our reckless burning of these same fossil fuels has caused environmental issues that will plague future generations. The time for changing the way humans view their daily activities is now and the sustainability movement must be a grassroots movement driven by the people. Americans must have a desire to live more sustainable lives by fundamentally changing the way they interact with their surrounding environment. This includes the economic, social and environmental impacts of all objects that are bought, used and discarded. In addition, as part of this movement, new technologies must be explored in an effort to replace our current sources of nonrenewable energy. Americans must develop new ideas and find innovative solutions, in an effort to replace the unsustainable daily activities of the average citizen.

Many Americans regularly exercise as part of their daily routine and this activity could become more sustainable. Exercising is not inherently unsustainable but the facilities in which Americans exercise, fitness centers, are highly unsustainable. Energy is wasted in fitness centers generally through inefficient practices such as leaving the lights on, keeping air conditioners cooling unnecessarily, fans running relentlessly, TV's constantly running, and unused

machines rarely being unplugged. Sustainable fitness centers would make significant strides towards addressing these unsustainable practices.

In order to fix the unsustainable aspects of a fitness center, the flow of energy within a fitness center must be understood. Heat is a byproduct of human exercise and therefore fitness center air conditioners must always be running. As humans exercise, the kinetic energy that they are burning is not converted directly into mechanical movement. Instead, humans sweat and they become increasingly hot allowing more thermal energy to quickly dissipate into the air. Humans sweat during a workout because the exercise equipment provides resistance to the user. Modern gym equipment is equipped with internal generators or alternators which power the control board. This control board is adjusted by the user to increase or decrease the level of resistance provided by the machine.

Exercise equipment that provides resistance through rotation of a fly wheel can be easily adapted to harness or capture some of the energy that was originally used to resist the users as they worked out. An example of this type of equipment would be elliptical machines, rowing machines or bicycles that already produce mechanical energy in a rotating form. Rotating mechanical energy is easily used to drive a propeller, generator, or other chain/belt. Although modern day exercise equipment uses some of this mechanical rotating energy to power a generator and subsequently electrical resistors, much of the energy is lost through heat. Sustainable gym equipment would allow the electrical and a portion of the thermal energy created by the user during a workout, to be utilized throughout the gym to power small voltage electrical equipment, such as lights or personal fans.

The potential for humans to power fitness centers is directly proportional to the amount of energy they are able to produce while working out. Steve Clinefelter, President of California Fitness explains the potential for human energy production, “One person has the ability of producing 50 watts of electricity per hour when exercising at a moderate pace,” (Powered by You). This means that if a person worked out for one hour on energy capturing exercise equipment they would produce enough energy to run a 50 watt light bulb for one hour.

There are many variables that control the amount of energy that is produced by the user during a workout such as the physical ability of the user. A generator that is attached to a typical energy harnessing piece of exercise equipment can deliver voltages between 15 to 70 volts depending on the rotation speed of the equipment. If this voltage could be controlled though a battery or an AC/DC converter to only output 25 volts regardless of the speed of rotation, then only the current would change (Motorwavegroup.com). Subsequently, the amount of watts produced would vary between 20 to 100 watts depending on the user’s physical condition.

The energy harnessing system must also be highly flexible to variations in user performance. Not only does the amount of watts produced fluctuate with the type of user, but also throughout a user’s workout. As an individual reaches their point of exhaustion, their power output deteriorates rapidly. Therefore, the energy capturing device must also be able to accommodate fluctuations within a person’s

workout in addition to variations between different users' overall physical conditions.

The total amount of energy that could be captured on energy harnessing exercise equipment is potentially very significant. It can be assumed that a fitness center that is open sixteen hours a day it has exercise equipment that is only used six to eight hours a day. This same equipment would be tied to lights that would only turn on when there are people using the fitness equipment. In addition, if the amount of energy saved by the gym users was monitored and connected to the air conditioner, it is feasible that the air conditioner would only turn on when there are people in the fitness center, rather than air conditioners working overtime in order to cool an already cool environment. In short, this type of sustainable fitness center would be saving energy in three ways. One, the energy to power the lights of the gym is harnessed from the gym users. Two, the other electrically powered equipment throughout the gym could be powered by the excess energy harnessed by the fitness center users. And three, since the air conditioner will be only used when there are fitness center users, the overall energy demand of the air conditioner would drastically decrease.

One company has created a similar type of sustainable fitness center that focuses on saving energy in these three ways, and the company has calculated that when they save 70 watt-hrs of energy per machine, in actuality they save 200 watt-hrs of energy (Motorwavegroup.com). In other words, with that type of savings readily available, a fitness center outfitted with forty pieces of energy conscious equipment could harness enough human energy to power several small

houses (Bathurst). Since this sustainable fitness center saves money on their electric bill each month, this company was able to pay back their initial investment to make their fitness center sustainable within three years.

Although reducing the total amount of energy used by a fitness center is the main goal of a sustainable fitness center, there are many other positive aspects of sustainable fitness centers. As part of the social sector of sustainability, sustainable fitness center also have a great deal of educational benefits. Some of the most difficult subjects to teach young students are new subjects that teachers and professors are not familiar with. Although sustainability is not a new topic, it is being introduced into every field of academia and sustainable fitness centers could become part of the educational process for K-12 students. Currently all elementary, middle and high schools have some form of a fitness center for their students to learn about physical education. These unsustainable fitness centers could be converted into sustainable fitness centers by retrofitting their existing exercise equipment with energy harnessing systems. This would allow the physical education teachers to teach their students about physical education and sustainability at the same time.

By integrating sustainable fitness centers into elementary, middle and high schools students would be able to learn about healthy living. Healthy living no longer means just eating the right diet, and getting enough exercise but it also includes sustainability. On the most fundamental level, the idea of living 'sustainably' refers to the notion that one's everyday actions and practices create a lifestyle that in turn produces a more healthy, habitable and equitable world for all

beings (Sustainable Education Handbook). Therefore being healthy also means living within a healthy environment. This is a very difficult topic for students to understand and for teachers to present. Sustainable fitness centers could be the answer for sustainability education.

This type of education could also be extended to other parts of society. Although it is a good idea for the next generation to learn about sustainability it is also important for older generations to learn about and practice sustainability. One of the benefits of sustainable fitness centers is that, the energy harnessing equipment system would not interfere with the user's workout. But the energy saved by the user during the workout could be displayed to the user. This information will educate the user in multiple ways. The user will literally be able to understand how much energy and work it takes to power the lights that are turned on when they start working out. If a user understands how difficult it is to power just a few lights they may be able to make the connection to how difficult it is to power the other electrical devices in their lives. Hopefully a workout at a sustainable fitness center will encourage the fitness center users to be sustainable throughout the rest of their day.

Sustainable fitness equipment, and in particular retrofitted sustainable fitness equipment, can also have positive economic benefits. As part of the three sectors of sustainability, sustainable fitness centers would spend much less money each year on electricity. But they would also spend less money each year on new fitness equipment. First of all, the type of sustainable fitness center equipment must be determined before discussing this topic. There are a few fitness centers

throughout the world that are currently sustainable. These fitness centers are owned by the aforementioned company California Fitness. California Fitness does not retrofit existing exercise equipment in an effort to be sustainable but rather they produce a special type of elliptical machine and upright bicycle that can harness human energy. This practice is inherently unsustainable, since they are using mass quantities of energy to manufacture and produce new exercise equipment. In addition, it does not make much economical sense to purchase all new equipment for a fitness center that is trying to be more sustainable when they already have a fitness center full of perfectly usable equipment.

It would make much more economic and environmental sense to retrofit all of the existing exercise equipment within a fitness center, with devices that would make the existing equipment sustainable. Since the existing fitness center does not need to buy all new equipment and they are not filling up landfills with their existing equipment, this is a much more sustainable practice as compared to purchasing all new sustainable equipment. In addition, the retrofitting system would increase the life span of the existing exercise equipment.

For most types of fitness center equipment the part that provides resistance against the user, breaks first. Mechanically, these pieces are the flywheel, motor and belts that connect the flywheel and motor. While the flywheel and belts are relatively inexpensive, the motor is generally the piece that causes the owner to deem the exercise equipment unusable. Not only does the motor allow the exercise equipment to provide resistance to the user, but it can also provide feedback to the user through a small electrical output.

A piece of exercise equipment that is retrofitted with an energy harnessing system would provide extended service life to the exercise equipment. The energy harnessing system would provide resistance to the user, and could be controlled by the user. In addition, the energy harnessing system would be providing feedback to the user about their workout in the form of a graph that would display their energy production. Since the retrofitting equipment would provide the same functions as the original exercise equipment's motor and flywheel, the overall service life of the bike would be extended.

As part of extending the service life of the retrofitted exercise equipment the retrofitting system must be able to provide the user with some sort of feedback. The most important type of feedback for the user of the exercise equipment is real-time feedback since the user most likely wants to know how they are working out while they are working out. Therefore as part of the retrofitting system there must be a monitoring device that takes a snapshot of how many volts and amps are being produced by the motor taken in very small intervals. Since the amount of volts and amps are known then amount of watts could be easily calculated and presented to the user in the form of a line chart, as the user works out.

In addition to monitoring the workout of an individual user as they work out, it is also desired that this information be logged and saved for later use. This information is desired so that individual pieces of exercise equipment can be compared based on their energy harnessing efficiency. This information can be useful in making adjustments to the calibration and configuration of the energy

harnessing system for different pieces of exercise equipment. Also, this information is crucial towards calculating the total amount of energy that can be saved by a sustainable fitness center over a long duration.

Sustainable fitness centers are one of the various ways that humans can integrate sustainability into their daily lives. Fitness centers that capture the energy that is usually a byproduct of exercising can be deemed locations of "parasitic" energy generation. The energy that is produced by these fitness centers is clean and renewable, a directly contrast from burning fossil fuels, which are neither clean nor renewable. Although "parasitic," the various data that is collected and presented to the user as feedback is the crucial link to educating the user about sustainability. Sustainable fitness centers will contribute towards reducing the overall energy demand and emissions created by humans, but by no means will sustainable fitness centers solve the energy crisis nor fix global warming. Rather the solution towards these problems, will be produced when the user of the sustainable exercise equipment will be educated enough to live a sustainable lifestyle.

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Appendix 1- Statement of the Problem

For this project, I wanted to develop a new kind of machine that could be easily incorporated into the lives of all humans, which would produce clean, renewable energy. Therefore, I needed to develop a system that could easily attach to an existing piece of fitness center equipment such as an elliptical, treadmill or upright bicycle that could be used by a wide range of users. Through the design and development stage of the project there were certain goals and benchmarks to be achieved. For this project design and development, an upright bicycle was chosen. The goals for the project are:

1. The retrofitting apparatus and energy capturing system must not interfere at all with the user's experience. Therefore the user would not have to change their workout to accommodate the equipment, making the retrofitted equipment much easier to integrate into the user's daily routine.
2. Sustainability in design. The parts and materials that were used for the project were selected in accordance with sustainable practice to the extent practical.
3. The fitness center user should receive feedback about the electricity generation and would be able to visually monitor how much energy they are producing during their work out.
4. The information that was used as a feedback loop for the user would also be logged and stored, so that it could be analyzed for further studies.

5. The energy produced by the user would be used within the fitness center.

Appendix 2- Procedures and Materials

A) Installation of 12vdc Motor, Site Powered Monitor and Shunt

Procedures

1. Disassemble the upright bicycles' outer shell.
2. Release the tension on the serpentine belt that connects the main fly wheel and alternator by loosening the alternators housing bracket.
3. Size the variable pitched pulley to the width of the serpentine belt.
4. Insert the variable pitched pulley on the Dayton 12vdc Motor. Make sure to tighten the set screw on the pulley to lock it in place.
5. Insert the pulley in between and in line with the alternator and flywheel pulleys.
6. Cut metal angle to create a supporting structure for the 12vdc motor. Make sure to connect the metal structure securely to the frame of the upright bicycle using 3/8inx2in hex screws. In addition use lock washers in the connection of the individual metal frame members to prevent the bolts and nuts from loosening while vibrating during use. (see Appendix 3-Pictures 1 and 2)
7. Attach the 12vdc motor using bolts to the top of the frame.
8. Insert another metal angle within the metal frame to support the Site Powered Monitor and Shunt.
9. Affix the site Powered Monitor and the Shunt on the metal support angle and within the frame of the metal support structure.

Materials

1. Life Cycle 9500HR Upright Bicycle
2. Dayton Permanent Magnet 12 Volt DC Motor
3. Grainger 1/2” Variable Pitched Pulley
4. Various sized (3/8inx2in) Hex bolts, nuts.
5. NewMar Site Power Monitor SPM-200
6. NewMar 100Amp Shunt

B) Installation of the electrical output system and monitoring device

Procedures

1. Cut a hole in the shell of the upright bicycle the same diameter as 12vdc single outlet.
2. Affix the 12vDC single outlet on the shell using the 12vDCs mounting bracket. (See Picture 3-12Vdc Single Outlet Mount)
3. Using light gage wire, and the one amp fuse connect the SPM- 200, the Shunt, the leads from the 12vDC single output and the motor in concordance with Appendix 4, Figure 1- Site Powered Monitor, Shunt, Load and Motor connection drawing
4. Secure all wires to the metal frame using electrical tape.

Materials

1. 12vDC single outlet, and mounting bracket
2. 1amp fuse and fuse holder
3. 16 gage wire
4. Electrical Tape

C) Installation of Protective Casing

Procedures

1. Cut the shell of the upright bicycle to accommodate the 12vDC motor and metal frame.
2. Cut the plastic Tupperware container to create brackets for attachment.
3. Heat the plastic slowly using a heat gun and bend the plastic into brackets
4. Attach the brackets to the shell of the upright bicycle using rubber washers, bolts and nuts. .(See Appendix 3- Picture4 Mounted Tupperware Brackets)
5. Attach the Tupperware container to the metal frame using plastic spacers, bolts and nuts.

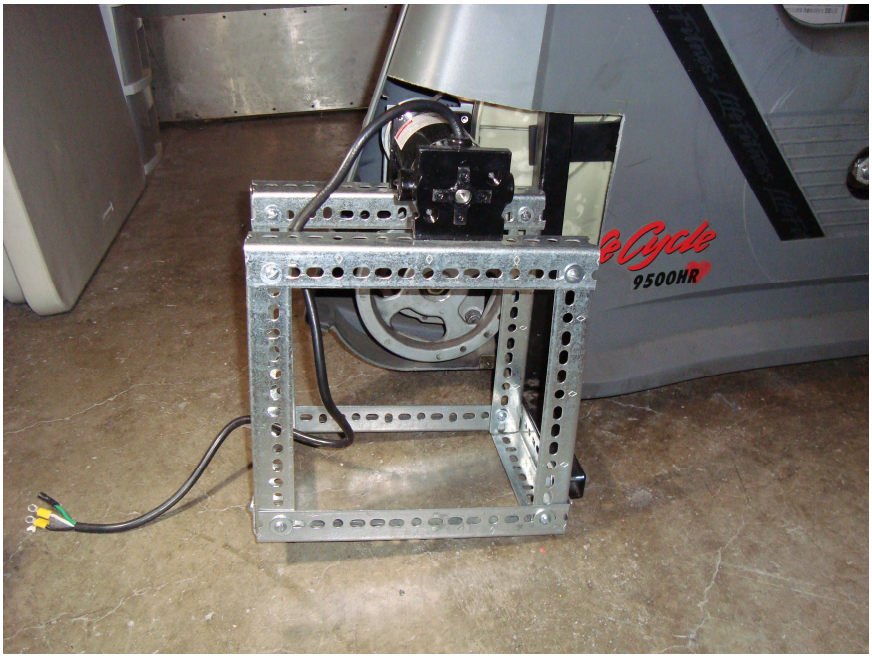
Materials

1. 17”x13”x22” Tupperware container
2. Various sized rubber washers, bolts and nuts
3. Plastic Spacers

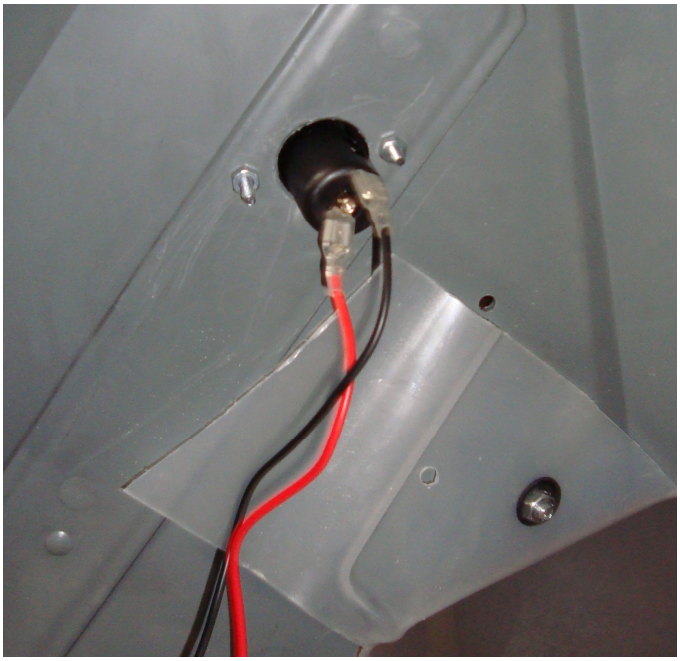
Appendix 3- Pictures

Picture 1-Metal Frame (Front View)

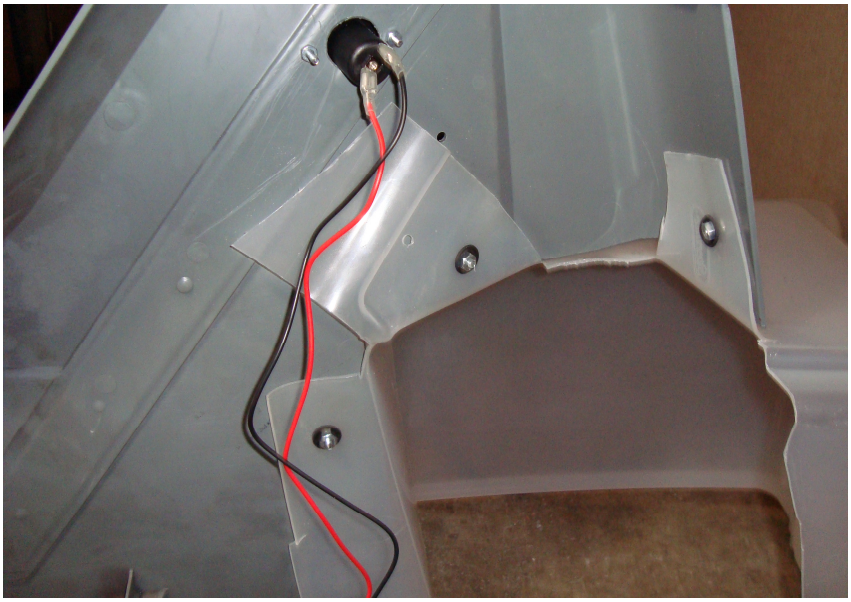
Picture 2- Metal Frame (Side View)



Picture 3-12Vdc Single Outlet Mount



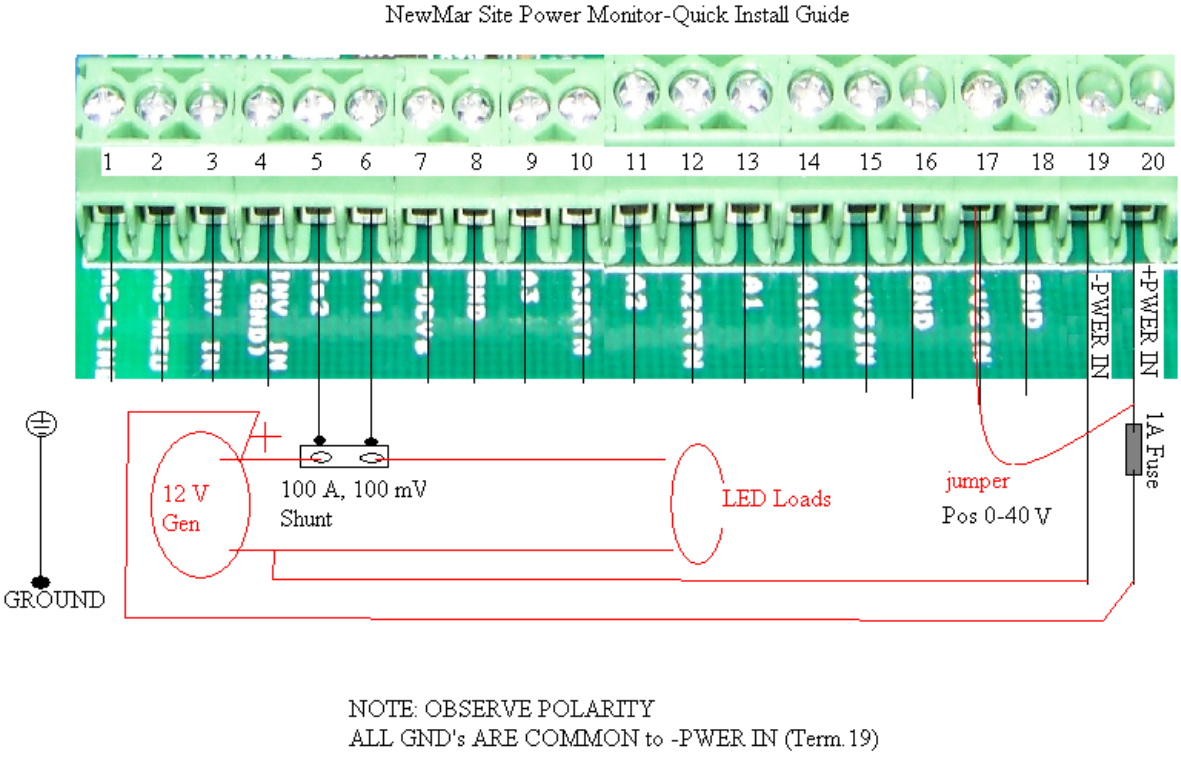
Picture 4- Mounted Tupperware Brackets



Picture 5-Final Product (Side View)

Appendix 4-Figures

Figure 1- Site Powered Monitor, Shunt, Load and Motor connection drawing



Appendix 5-Conclusion and Recommendations

The first prototype was a success since it met all project objectives but there is room for improvement. This set up successfully harnesses the users electricity to power three 6.3 volt, 250mamp light bulbs and the amount of watts produced by the user can be displayed in real time in addition to being logged and stored. The set up does not interfere with the users work out and is completely safe for exercisers of all ages.

There are some parts of the energy harnessing set up that should be replaced to make the setup more efficient. This set up could be improved by replacing the variable pitched pulley with a serpentine pulley that is sized for the serpentine belt. There is slippage and a loss of efficiency at the variable pitched pulley/serpentine belt interface.

Capstone Summary

Sustainable fitness centers are a vision for the future. The vision includes a world where humans are sustainable in every aspect of their daily lives and with every decision that a person makes, they consciously consider the environmental impact of that decision. But sustainability encompasses much more than just reducing the human impact on the environment. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In addition, sustainability has three main branches which include environmental, economic, and social sustainability.

In order to maintain sustainability, Earth's resources would need to be used at a rate not faster than they can be replenished. Scientists have discovered that the Earth has been gradually warming over the past few decades. Natural cycles within the Earth's climate, at this time, cannot fully explain the relatively large increases in surface temperature in such a short amount of time. Therefore, something else must be occurring within the atmosphere that is causing the rapid increase in Earth's surface temperatures. Human activity is most likely the cause of the increased temperatures around the globe. Humans contribute to global warming by increasing the amount of greenhouse gasses within the Earth's atmosphere. Everyday activities such as driving a car, or plugging in a hair dryer increase the amount of greenhouse gases in the atmosphere. While greenhouse gasses are directly attributed to the burning or combustion of fossil fuels, these mundane everyday tasks contribute as well.

The combustion of fossil fuels is the main source of energy for cars, as well as electricity production. Therefore, the amount of greenhouse gasses within

the atmosphere is linked to the level of development of a particular country. There are six greenhouse gases; carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons, and water vapor. In order to reduce the amount of greenhouse gases, humans need to live more sustainable lives by using energy that is produced from alternative sources.

Although wind, solar, nuclear, geothermal, biomass and tidal energies are useful alternative to fossil fuels, these are not the only types of alternative energy. Humans create large amounts of kinetic energy every day, through various activities such as walking and eating. Unfortunately, most of this energy is wasted. One location where people congregate to expend energy is at fitness centers. The reason why most humans work out is because they want to be healthier, and in the process they burn calories. Sustainable fitness centers would no longer have this energy go to waste but rather, it could be captured and used within the fitness center. Some of the fitness equipment that is most widely used includes rowing machines, treadmills and upright and reclining bicycles. A sustainable fitness center would need to include rowing machines, treadmills and upright bicycles that capture energy.

An effective way to capture energy on these types of machines would be through redesigning the basic components of the equipment. This would include research and development of new designs for these types of machines. A thorough redesign might render all of the existing equipment throughout the world's hundreds of thousands of fitness center facilities, obsolete. Instead of throwing all of this perfectly capable and functional equipment away, I have developed a way

to retrofit the existing equipment to harness human energy. This means that all of the existing equipment would not need to be thrown away, making retrofitting a more sustainable option than redesign and redeveloping new exercise equipment.

Through the design and development stage of the project there were certain goals and benchmarks to be achieved. For this project design and development, an upright bicycle was chosen. The goals for the project are:

6. The retrofitting apparatus and energy capturing system must not interfere at all with the user's experience. Therefore the user would not have to change their workout to accommodate the equipment, making the retrofitted equipment much easier to integrate into the user's daily routine.
7. Sustainability in design. The parts and materials that were used for the project were selected in accordance with sustainable practice to the extent practical.
8. The fitness center user should receive feedback about the electricity generation and would be able to visually monitor how much energy they are producing during their work out.
9. The information that was used as a feedback loop for the user would also be logged and stored, so that it could be analyzed for further studies.
10. The energy produced by the user would be used within the fitness center.

The project was successful in meeting all of these goals. The system used to capture the energy spent by the fitness center user included a direct current motor run in reverse, therefore making it a generator, a serpentine belt, a variable pitched pulley, a remote site powered monitor, circuitry, and a 12 vdc docking station. The generator is the heart of the project and it is connected to the bicycle by the same serpentine belt that drives the bicycles' flywheel. The remote site powered monitor is used to log in real-time the amount of volts that are being harnessed by the user. In addition, this device logs and stores the data for a period of forty days. The 12 vdc docking station makes the energy capturing device's output versatile. The docking station is affixed to the side of the bicycle and can accommodate any type of electronic device that can also be plugged into a car. This means that the user could plug in their cell phone or iPod charger into the bicycle's docking station and charge their electrical devices. The output of this docking station could alternatively be used to power lights and other types of equipment throughout the fitness center.

The benefits of a sustainable fitness center are far reaching and satisfy the three sectors of sustainability. If enough exercising equipment was retrofitted with energy capturing devices, the fitness center could possibly power itself. The fitness center would no longer need to import "dirty energy" from the grid. The current energy supply within the United States is created in large part using fossil fuels such as oil and coal. If a fitness center was no longer using grid energy, the impact of that particular fitness center on the environment would decrease. A sustainable fitness center could also be a place of education for people of all ages.

As a person works out on an energy harnessing piece of exercise equipment they would be learning how much physical work it takes to produce nominal amounts of energy. For example, after learning how much work it takes to produce just one watt, that person would be less likely to leave the lights on in their home, or even drive their car to the fitness center. It is learning through experience.

What about the bottom line cost of retrofitting? In short, the cost is minimal compared to the benefits that sustainable fitness centers produce. In addition, retrofitting fitness center equipment to serve as "energy harnessers" will allow the fitness center owner to advertise that their fitness center is a "green fitness center." This would likely cause an increase in the number of memberships since healthy people like to work out in healthy places, such as a sustainable fitness center. Lastly, sustainable fitness centers are cost effective. Instead of looking at the installation cost of one retrofitting system, look into the life cycle cost of that piece of equipment. The piece of fitness center equipment will harness kinetic energy and allow that energy to be used within the fitness center. If the fitness center requires no input from the energy grid the fitness center owner no longer has to pay energy bills. This type of technology also allows the fitness center owner to extend the life of their exercising equipment. Usually the first part of an exercise machine that breaks and causes the owner to regard it as unusable, is the electrical system. By incorporating a retrofitted energy harnessing system into the fitness center equipment, the user will have two forms of feedback. One form of feedback will come from the equipment's existing system and a second, through the feedback produced by the energy harnessing system. Sustainable

fitness centers address the social, economic and environmental aspects of sustainability.

Humans need to start transforming the way they live, so that they are more sustainable. But this change is not going to happen overnight nor is it going to be easy to convince everyone that a change is necessary. That is why innovative products such sustainable fitness center equipment needs to passively make humans more sustainable. By producing fitness center equipment that does not impact a user's workout the user is going to be less reluctant to switch over to the sustainable fitness center equipment. In addition while that person is on that piece of equipment they will learn about energy by experiencing what it takes to produce energy. Sustainability needs to be integrated into our society by changing the way people think, and sustainable fitness center equipment can be one part of the global movement towards thinking sustainably.