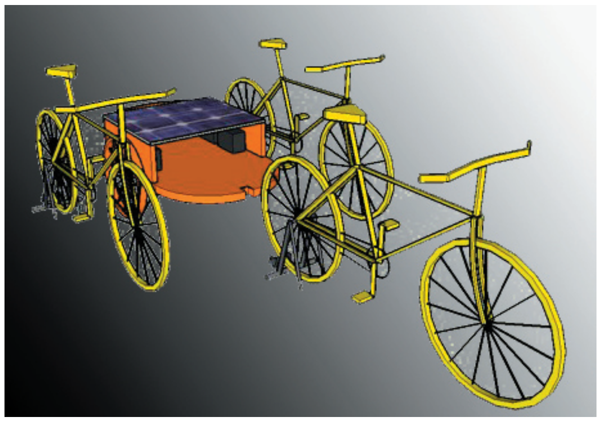
Portable Pedal Power

A proposal for AAA and Burt Rutan
March 1, 2005

Submitted by CASL and the EDC



Outline of Portable Pedal Power Proposal:

Portable Pedal Power Proposal

Abstract:

Living in America in the 21st Century is a luxury that is generally taken for granted. It wasn't long ago that people lived in small houses without flush toilets, running water, or electricity, and now people don't even recognize the great ingenuity that is required to bring electricity in to our lives. Our proposal seeks to raise hands on awareness of electricity production, while demonstrating alternatives to the current standard in an exciting and engaging way.

It is important to visualize new ways to bring power to the people as population continues to grow and power shortages continue to occur. Much of the power that is provided to people today is done in very un-sustainable ways; new ideas are needed to transition in to a post cheap-petroleum era.

Proposal:

We propose to design and create a portable bicycle trailor that generates electricity for events and demonstrations. The trailor will be fully equipped with bicycle stands that fold out to handle 3-4 bicycles. Each stand would be connected to a small magnet motor generator that would transform the bicycle pedal rotations in to electrical energy. The energy then charges a small battery bank. From the batteries, users will have the option of powering directly with DC current appliances or plugging in to a connected AC inverter. This will generate aprroximately 300-500 watts of electricity for a sustained amount of time figuring 3-4 bicyclers at a moderate pace. Additional power can come from trailor-in-motion generation, and an integrated silicon solar cell.

Project participants will gather information and produce sketches to capture initial ideas before April 24th. When Burt Rutan arrives on the 24th a charrette type activity can take place where groups will collaborate on designs within a limited time with the assistance of Burt Rutan. After this process, group members will reconvene to synthesize the designs and information in to dimensioned drawings to be constructed by local bicycle and trailor builder CAT. Group members can order all required parts and assemble much of it in workshops. Final touches will be made by art, metalsmithing, and design students. The process and outcome will be well documented by multimedia and video students as well as journalism students for publication in magazines like *Home Power*.

Specific Selection Criteria:

1. Promise to inspire participants to visualize and create beyond traditional limits:

Most components of the portable pedal power generator are based upon existing inventions, both recent and historic. The real innovation behind this power generator is portability. University groups often organize events around and off campus. Therefore, mobility of equipment is of great importance. This innovation brings together the resourcefulness of pedal power generation with the transportation feasibility of a bicycle trailor. The integrated unit will generate needed electricity on-site, and transport it to the site with pedal power. During transportation, the unit can also capture energy used in braking and coasting. A photovoltaic panel could further the energy production while demonstrating the portable potential. We think our pedal-powered device will inspire students and the public to think about the realities of energy production, which may spark new energy solutions.

2. Promise to engage students and faculty from multiple disciplines within AAA:

Though everyone at the university will be welcome to be involved in the project, AAA students and faculty should find specific appeal because the multiple stages of the project will require the skills of those adept in collaboration between various disciplines within the School of Architecture and Allied Arts.
All design students will be intrigued by the design, the aesthetics, and how it relates to the human and built scale. Interiors students will be able to relate to the project's ergonomics: shaping it in to a finely crafted piece of furniture. These students are familiar with translating a set of design requirements into real visions and

plans, sections, and 3-d models. The Portable Pedal Power is similar to one of our existing design-build studios or the ever-popular Furniture Studio. Art, sculpture and metals students will be able to artistically design, create and weld: the Portable Pedal Power must be eye-catching and intriguing, as well as functional. PPPM students will be excited to work on something real: for while they take classes on transportation, sustainability, energy, and growth patterns, they get too few chances to act and design. To make the Portable Pedal Power a reality, we want and need the skills and design talents of all AAA and beyond.

3. Demonstrate how they would result in a creative product (i.e. exhibit, publication, or object) to mark the event:

Portable pedal power generation will be a viable example of an innovative solutions to issues of excessive non-renewable energy consumption. Video documentation of this demonstration will be made to show at future pedal powered events and to share the innovation with other interested groups. Both the Center for the Advancement of Sustainable Living (CASL) and the Ecological Design Center (EDC) will use the device for periodic events. The Pedal Power Device would be made available for trial and inspection at the CASL house to inspire and educate interested people.

The Portable Pedal Power device is an awesome initiative for the AAA and Burt Rutan.

The workshop with Burt Rutan will be a hotbed of innovative design; a kick-off to the process of building, creating, and using the Portable Pedal Power for years to come. The Portable Pedal Power is not a static artifact, or a mere video, nor a publication doomed to sit on a dusty shelf. It is ongoing and interactive, a useful, inspiring machine. We expect our machine to inspire future projects, just as ours has been inspired by precedents. It is time to expose Eugene to Pedal Power, as there is no demonstration of it in the area.

Multi-Disciplined Group Collaboration

The Group supporting this project is composed of people from numerous majors and backgrounds. Two student groups, CASL and the EDC have decided to collaborate because they see this project as an important piece of equiptment that will benefit both groups as well as the students at large. In addition to these two groups, composed mostly of architecture students but also including a large variety of disciplines, students outside these two groups are involved in this project.

CASL is a Student Group made up of a variety of disciplines. The mission statement is:

The mission of the Center for the Advancement of Sustainable Living (CASL) is to demonstrate ecologically and socially sustainable technologies and living practices in a residential setting, to provide hands-on experiential learning opportunities for the University of Oregon and surrounding communities, to collect and disseminate information about such technologies and practices, and to facilitate original research in this field. CASL is dedicated to challenging the notion that living lightly is difficult or burdensome.

Coordinators:

-Co-Directors:	Sebastian Collet, Architecture
	James Hiebert, PhD Computer Information Science
	Rodrigo Moreno Villamar, Environmental Studies/Anthropology
-Treasurer:	Genevra Csipkay-Brehm, ...
-Publicity & PR:	Chris Gamman: Social Studies
-Workshop & Events:	Leda Grembowski: Education
-Information:	Nathan Dinihian: Multimedia

The EDC (Ecological Design Center) is made up of all design students in the AAA department. The mission statement is:

The relationship between the built and natural worlds must be sustainable. The EDC believes designers should pioneer this relationship. The EDC seeks to educate and inspire University of Oregon design students to have the awareness, sensitivity, and expertise to lead the community toward sustainability. While the EDC's focus is in the design disciplines, we welcome interested students and community members of all fields.
our mission is to:
* Advocate for an interdisciplinary ecological design curriculum for AAA students,
* Cultivate networking opportunities for AAA students with professionals practicing sustainable design of the built environment,
* Create a forum for ecological design dialogue through the HOPES conference, traditional and digital publications, and on-going events,
* Advocate for and implement ecological planning and design on the University of Oregon campus and Eugene community.

Coordinators:

-EDC director:	Martha Bohm, Graduate Student Architecture
-Curriculum:	Sebastian Collet, Undergraduate Student Architecture
	Kennett Payne, Graduate Student Architecture
-Finances:	Roxanne Coulter, Graduate Student Architecture
-Library:	Sam Jensen Augustine, Graduate Student Architecture
-Portland EDC:	Tim Cooke, Undergraduate Student Architecture
	Erin Hastings, Undergraduate Student Architecture
-Public relations/communications:	Lilah Glick, Graduate Student Planning
-HOPES director:	Susan Thompson, Undergraduate Student Architecture
-Publications: print:	Chris Legg, Undergraduate Student Architecture
-Publications: web:	Phillip Jones, Graduate Student Architecture
-Professional development:	Marsha Garcia, Graduate Student Architecture
-Solar project:	Chris Cottrell, Graduate Student Architecture
-Speakers:	Jessy Olson, Undergraduate Student Architecture
-Workshops & events:	Zac Moran, Undergraduate Student Architecture

Additional Students:

Art: Casey Wanlass
Architecture: Michael Hahn

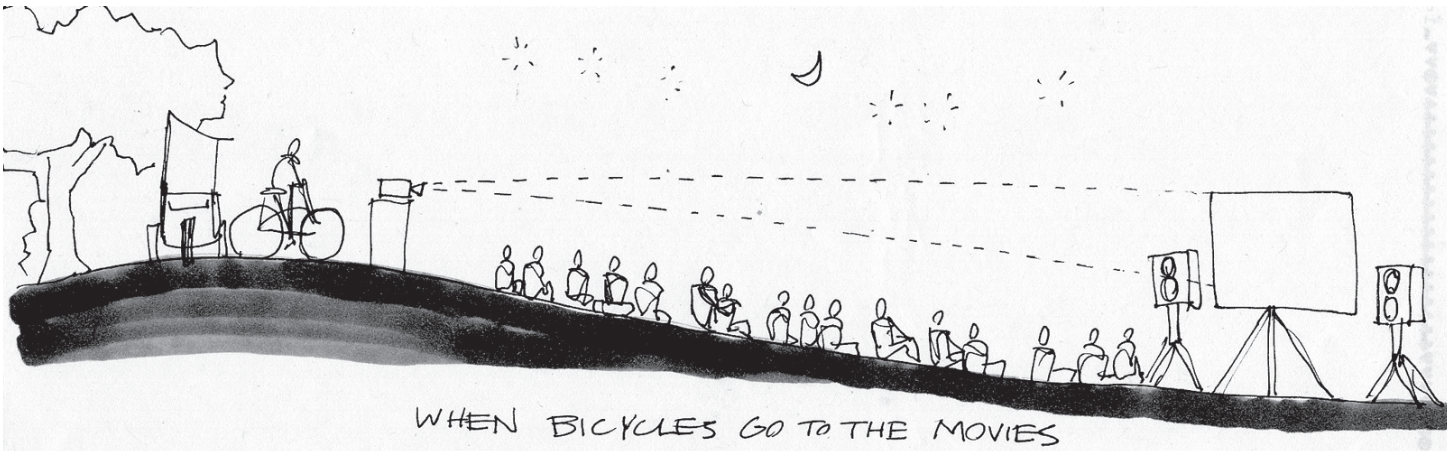
Faculty:

Physics Professor: Dean Lively-Brooks
Our initial Faculty team member has lots of experience with solar and renewable energy.

For more information on the EDC please visit the website at: http://edc.uoregon.edu/
For more information on the CASL group visitthe website at: http://darkwing.uoregon.edu/~casl/

Preliminary Design

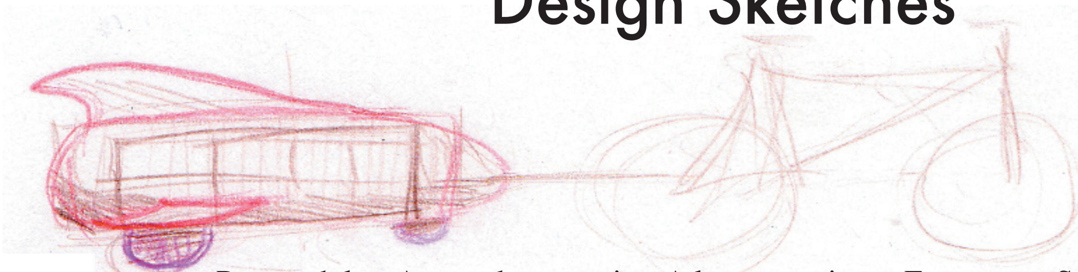
Imagine walking down the main street of campus, you see a crowd of people standing around something large. You squeeze your way into the crowd to see what's going on. Three cyclists are are spinning their bikes in place, in front of a dazzling trailer structure. Blenders are whirring, several of them, making cold smoothies for the hot day. The cyclists are laughing and seeing how much power they can collectively make. A simple display explains that the cycles are generating electricity!
...or...
Friday night on campus on a grassy lawn, a group is setting up to show a movie. They've got the usual set-up: screen, speakers, projectors… but what's off to the side? The portable Panther, a pedal powered portable event generator will be providing for tonights show...



Design Guidelines:

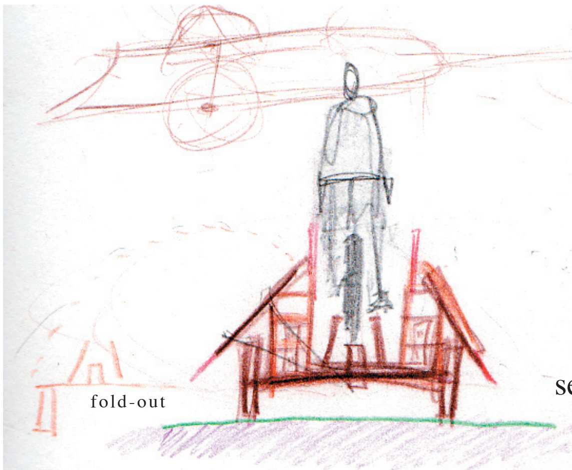
1. Safe for Bicycle Users, Staff and Observers
2. Transported by bicycle
3. Fits in a bike lane (manageable size)
4. Convertible from a mobile trailer to an amazing energy generator
5. Power production
    a. Must incorporate standard bicycles
        i. Modularity: Visitors' bicycles can be easily plugged in
    b. Must generate enough power to run a variety of small appliances (AC or DC) or a speaker system
    c. Contains batteries for storing power
    d. System allows for future expansion: more bikes, more batteries, higher power capacity
    e. System allows for adding on other energy sources such as photovoltaics
6. User interaction:
    a. Attractive, understandable and inspiring
    b. Fun to participate in cycling
    c. Educational displays and electricity meters which are easy to understand and visible to both cyclists and observers
7. Easy and interesting transformation from portable trailor into powerful pedal power generator.
8. Potential for future additions.

Design Sketches

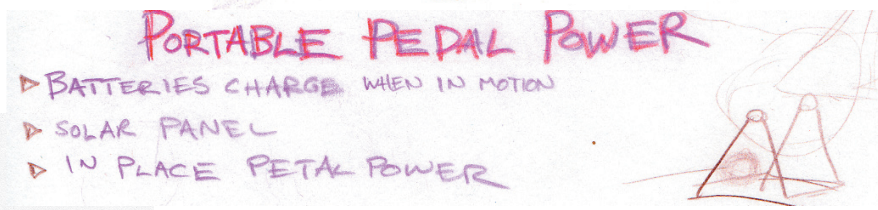


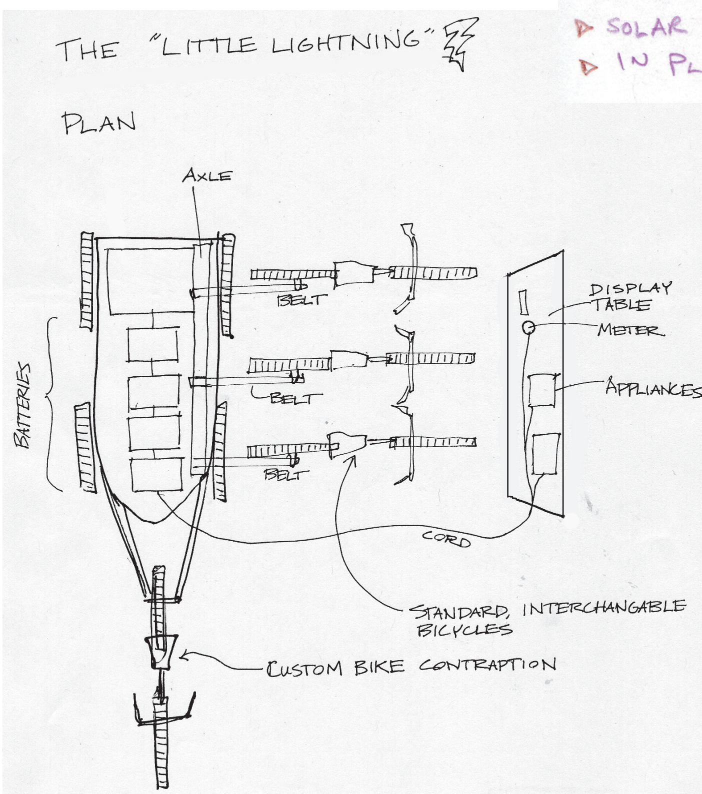
Portable Aerodynamic Alternative Energy Source

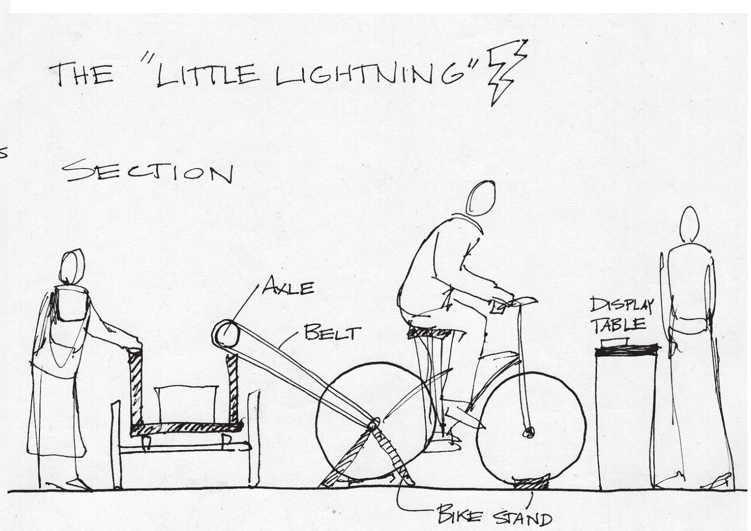
Potential telescoping photovoltaic shading device.



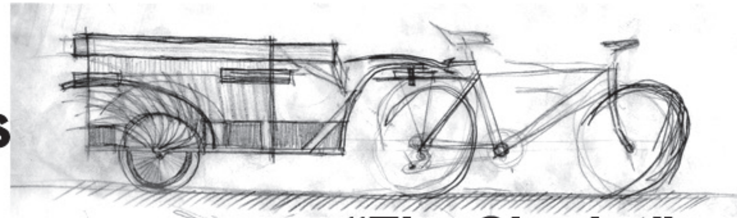
sections



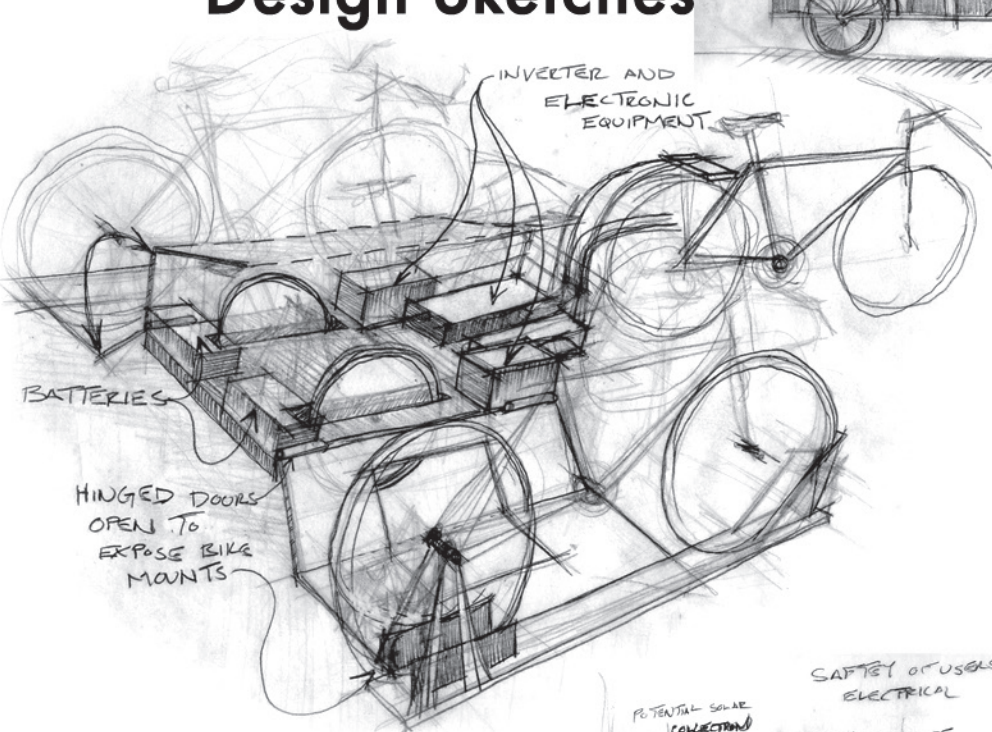


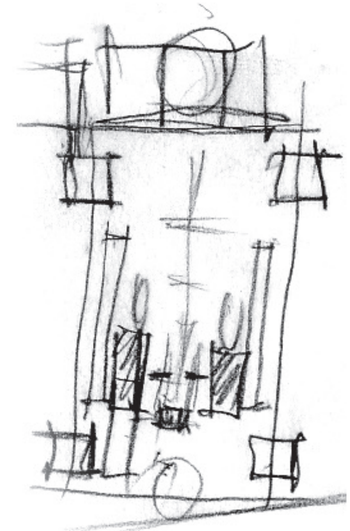


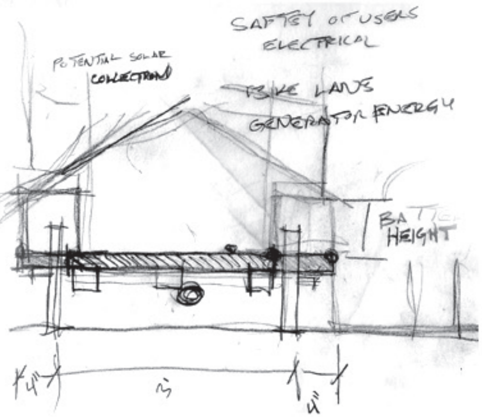
Design Sketches

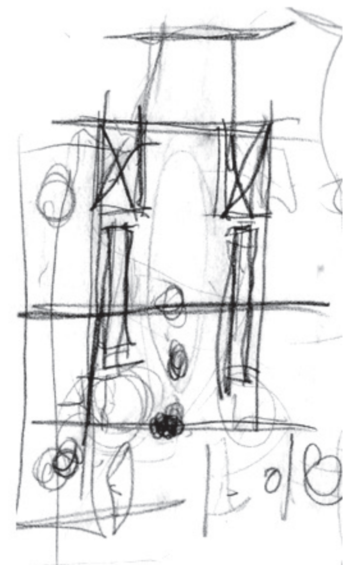


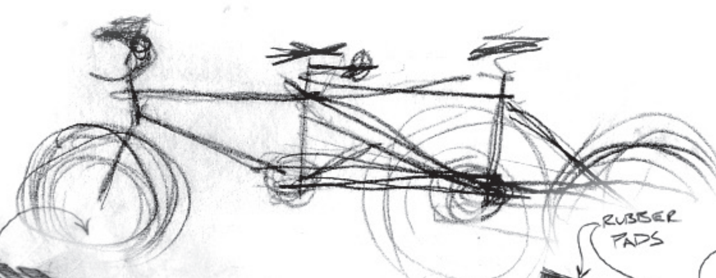
"The Chariot"

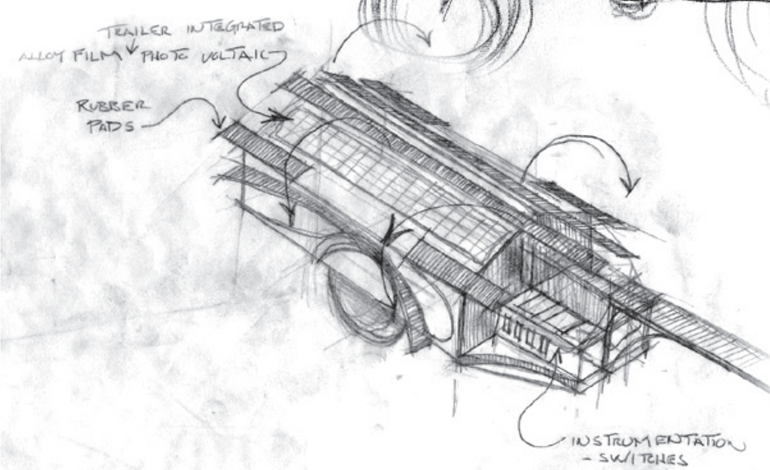


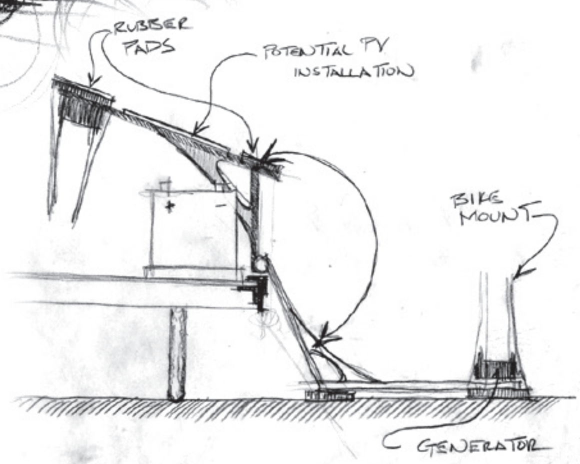




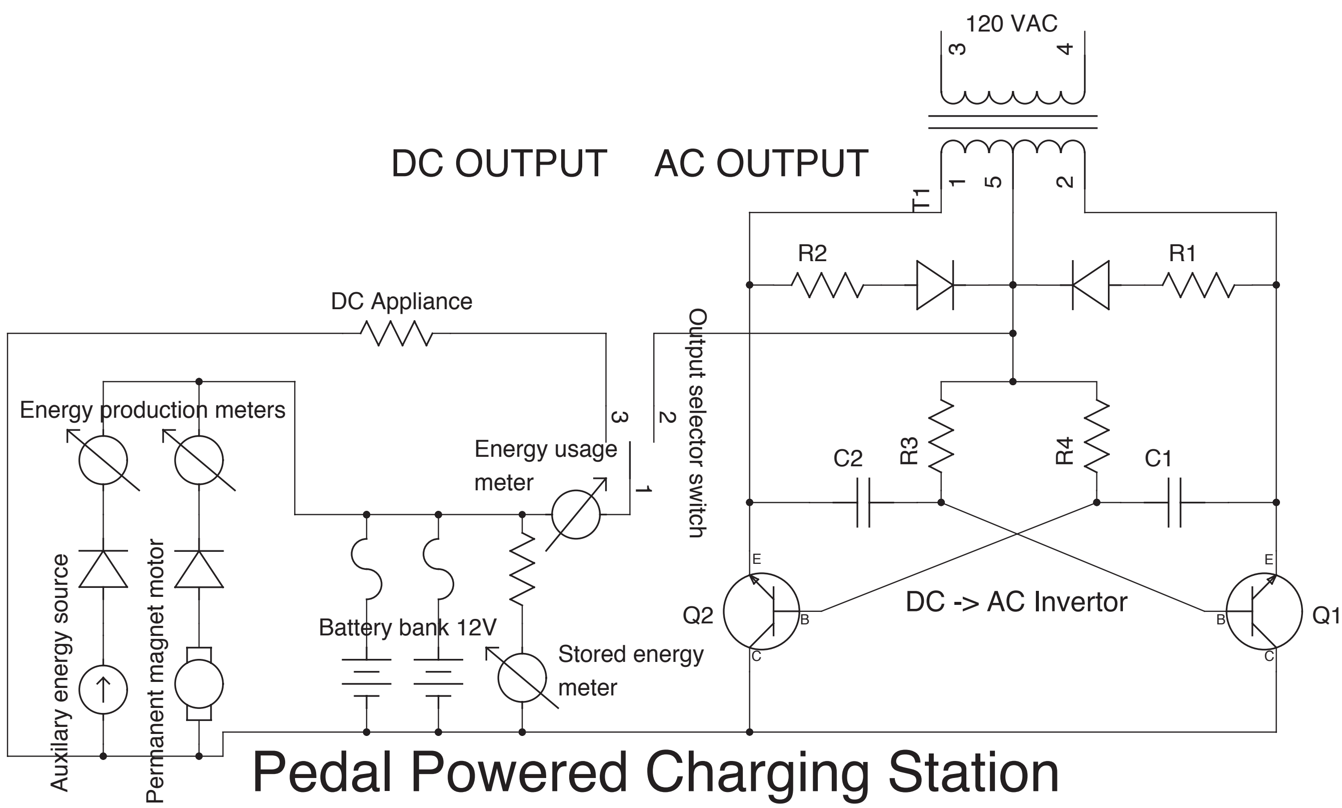








Initial Electrical Schematic



Pedal Powered Charging Station
with AC/DC Output and
4.4 KWH Battery Bank

Projected Budget

Category	Item	Cost	Quantity	Total
Unit Transportation (custom, cargo bike)				
	Bicycle parts	1500	1	1500
	Design and production labor	1500	1	1500
				3000
Power Generation and Storage				
	Permanent magnet motor (500-1000 RPM, half-1 HP)	300	1	300
	DC to AC Invertor (half KW)	100	1	100
	Bicycle training stand	100	3	300
	Auxilary power source (e.g. PV, micro wind)	300	1	300
	Wiring, fuses, informational displays	50	1	50
	Output selector switch, output plugs	50	1	50
	Deep cycle battery (6 or 12 V, 2-4 KWH)	200	2	400
				1500
Artistic Design				
	Sculptural metal and welding materials	100	1	100
	Paint	50	1	50
	Interpretive sign materials	50	1	50
				200
Project Documentation				
	Videographer fees, tapes	300	1	300
				300
			Total	***5000***

Additional Background Material...

Basic Pedal Power Study

http://users.erols.com/mshaver/bikegen.htm

I skim a few Usenet newsgroups daily, among them misc.survivalism and alt.energy.homepower. Frequently posters on these two groups will inquire about generating electricity using a stationary bike coupled to some sort of generator. Most replies are to the effect that while it's possible to do this, the amount of power output by such a rig when pedaled by the average person wouldn't be worth the effort. I wasn't convinced that this idea was a lost cause. I decided to build one and see how well it worked.

Because bikes are made in a range of sizes to match their rider's stature I wanted to build the generator as an accessory which could be driven by any ordinary bicycle. I used to work in a bicycle shop when I was 13 and remember seeing the owner, Mr. Hank, ride his track bike on a set of rollers. While I was looking through bike accessory catalogs for rollers that I could adapt to my purposes I came across another similar device called a training stand. While rollers require a lot of skill to ride because there is nothing but the gyroscopic force of the spinning wheels and the rider's balance to hold you upright, a training stand clamps on the rear axle of the bike and keeps you vertical.

To make a long story short I bought the most versatile training stand I could find and then did extensive modifications to the roller assembly. Originally the ball bearings were pressed into the bore of the roller at the outer ends. The roller assembly spun on a stationary axle fixed to the frame. The end of the roller, opposite the integral three pound flywheel, drove the hub of a centrifugal clutch. The shoes of the clutch engaged a stationary drum which provided resistance increasing with speed. I had to make a new axle which is locked to the roller and move the bearings to machined aluminum plates outboard of the steel frame. The plates are made to a standard NEMA 42 size and provide the mounting surface for a permanent magnet DC motor that is driven as a generator through a flexible coupling. The other end of the axle exits from the bearing through an identical plate and is available for PTO use. You can see a black sprocket on that end of the axle in the pictures. I also had to weld in a brace to stiffen up the frame to allow carrying the extra weight of the generator. I'm pleased with the result. Even under heavy load it runs cool and relatively friction free. The part of the frame that clamps to the rear axle of the bike pivots with respect to the ground so that the rider's entire weight forces the tire into contact with the roller reducing slippage to a minimum. The black object under the front wheel is a contoured plastic block that levels the bike to avoid the feeling of riding downhill.

I have done quite a few tests to see how much output power could be produced and what practical applications there were. See the tables below for a list of those tests and the results. In summary I think the most practical application of the bicycle powered generator would be battery charging. This application presents a constant load to the rider which allows them to select a single gear ratio which lets them pedal at their optimal cadence. Another practical application is running small appliances and tools which use universal series wound motors or permanent magnet DC motors. All of the motorized items in the table below have universal series wound motors and would run on DC even though their nameplates all said "120 Volts AC Only". Induction type motors such as those found in washing machines and shaded pole motors which are used in clocks really are AC only and won't work at all. I couldn't get my variable speed drill to work, probably because the speed control electronics are incompatible with DC. Good candidates are appliances or tools that can perform their functions with 300 watts of input power or less and which present a narrow range of loads such as the mixer and electric drill. Although producing heat with electricity is usually a bad idea, I think that small soldering irons might also work well since they are almost all are under 100 watts and most are less than 50 watts. Since there is no voltage regulation at all, connecting the generator output directly to the power input jack of battery powered TVs, radios, and similar devices will probably destroy the sensitive electronics. Use the generator to charge the batteries, and power the electronics from the batteries. Since the generator is capable of outputting several amps it may be best to charge only batteries that can accept a charging rate in this range, and then building an efficient switchmode regulator to charge smaller cells and batteries off of the large battery. The final, and as yet unexplored, application is hitching mechanical loads such as a water pump or grain grinder to the PTO end of the axle using roller chain. I expect a lot more useful work out of this arrangement as it avoids the inefficient conversion of the rider's mechanical energy into electricity and then back to mechanical energy via electric motors. Using 27" tire diameter on the bike and a 10 MPH "road speed" the roller will turn at about 2600 RPM. The sprocket shown is the smallest I could find at 9 teeth for 1/2" pitch #41 chain, so you would need to figure from there what size sprocket you need on the load to give the desired load RPM. One suggestion that came up during testing was to drive a heavy flywheel to dampen out electrical load variations, but that was

Electrical Tests:

Load	Output	Comments
Open Circuit	230 Volts DC	Spinning it as fast as possible in the highest gear that the test bike had and measuring the output with a DMM.
Short Circuit	4 to 5 Amps DC	Generator output shorted by the DMM on the 20A DC scale. This measurement doesn't mean much because it took a lot of torque to turn the generator against a short circuit. It was hard to get consistent readings due to the speed fluctuations from the low rate of pedaling that could be achieved.
2 Ohm Wirewound Resistor	5.5 to 6 Volts DC (15 to 18 Watts)	This test had the same problem as the short circuit current test, the load impedance was too low to allow the rider to pedal effectively.
65 Ohm Wirewound Resistor	100 Volts DC (150 Watts) Continuous, 130 Volts DC (260 Watts) Peak	The continuous figure is what the rider felt he could keep up for 15 to 30 minutes. The peak value was a few second burst of speed.
100 Ohm Wirewound Resistor	100 Volts DC (100 Watts) Continuous, 150 Volts DC (225 Watts) Peak	The difference between this test and the previous one could be variability of effort on the part of the rider, perhaps as a result of fatigue. Another possibility is impedance mismatch between the source (generator) and load. The generator has a very low output impedance and the ideal load would be the lowest resistance that will still allow the rider to pedal at an effective rate.

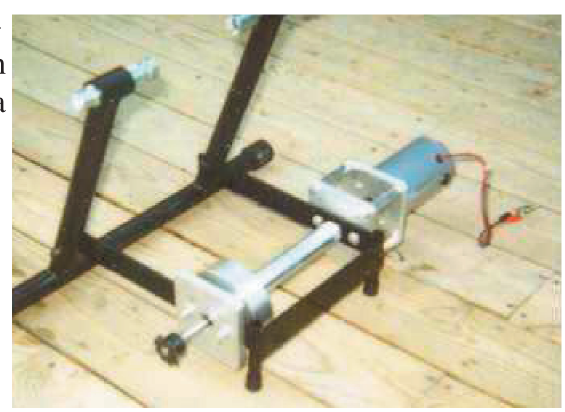
Practical tests:

Load (Nameplate Data)	Results	Comments
Battery Charging	Great	Able to push a continuous 4 to 6 amps into a 12 Volt automobile battery. The best setup was to put a rectifier diode in series with the generator output. This stopped the battery current from driving the generator backwards and enabled the rider to start pedaling without any initial resistance. It was then possible to take up the charging current load gradually as the generator output exceeded the battery voltage plus the forward voltage drop across the diode.
Waring Multispeed Handmixer	Good	Moderate pedaling effort was required to run this appliance up to operating speed. I loaded the motor by trying to slow the rotation of the beaters by hand. There was plenty of available torque to use the mixer in its typical applications. I'm certain that similar appliances such as blenders and food processors would work just as well.
Black & Decker 3/8" Drill Model 7104 Type 1 (2.9 Amps 1200 RPM)	Fair	Lots of 1/4" holes were drilled through a 2" thick piece of framing lumber with a standard high speed twist drill and I'm sure that larger holes would be possible. The only special consideration was to ensure a steady feed rate while drilling to avoid load fluctuations.
Black & Decker 7-1/4" Circular Saw Model 7308 Type 5(1-1/2 HP 9 Amps 1200 RPM)	Poor	Considerable pedaling effort was required to get the saw up to operating speed and it bogged down to a standstill when a cut through a 2 x 4 was tried. We might have been able to cut 1/4" plywood or luan. I think the problem is that the motor in this tool is designed for maximum power output regardless of conversion efficiency. I'm sure a person has enough power to saw a board, after all, I can do it with a hand saw using only the muscles in one arm! I would like to try this test with a saw designed to run efficiently on DC such as the battery operated ones made by DeWalt.
McCulloch ElectraMac Chainsaw Model EM14ES (2 HP 11Amps)	Useless	This tool's motor has the same characteristics as the circular saw. It was impossible to get it up to full speed, and the blade merely bounced off the surface of the log and stalled when any meaningful cutting force was applied. The nameplate claimed 2 horsepower and the motor's size was perhaps 3" in diameter and 6" long.

Acknowledgements:

During my "what if" phase of research on the internet I was directed to David Butcher's Pedal Generator page which provided me with the proof of concept I needed to justify building my own version of a bicycle powered generator. I think my results correlate well with his.

I would also like to thank my long time friend Mike who spent several hours with his Paramount mountain bike clamped in my contraption pedaling diligently while I measured and fiddled around. For reference he is in his mid 50's, in good physical health, a non-smoker and semi-regular recreational cyclist, so you can scale your own expectations accordingly.



AVAILABLE PRODUCTS

Real Goods

Bike Generator & Stand - $639.00
The human body can be highly efficient at delivering energy. Most adults can generate a steady 75 to 150 watts with spurts of double that power. Our bike generator provides a sturdy, adjustable stand that raises and clamps the rear axle of your bike, with an adjustable friction wheel, a flywheel for steady power, and a DC generator that can deliver over 500 watts. Evven Lance Armstrong could find his comfort zone on this powerful bike generator. Many off-the-grid parents require their kids to power their TV watching with our bike generator. The stand has large, heavy rubber feet for stability and quiet. The generator will deliver 12V or 24V power depending on the battery it's connected to use higher gears with higher voltage. Charge your off-grid or RV household battery, or any portable battery pack. Bike not included. Stand made in Japan, generator made in USA. Gift wrap not available.

Uni-Solar Marine Flex USF-32 -$395

These flexible Uni-Solar triple junction modules can be rolled down to an 8-inch diameter without damage. Features blocking diodes within the potted junction block to prevent battery discharge and nickel-plated brass grommets at corners. Includes eight feet of cable with built-in fuse holder and a 2-pin SAE connector. This is the type of module chosen for the Horseback America Expedition. USA.

- Rated Watts: 32.0 watts @ 25°C
- Rated Power: 16.5 volts @ 1.94 amps
- Open Circuit Volts: 23.8 volts @ 25°C
- Short Circuit Amps: 2.40 amps @ 25°C
- L x W x D: 56.3" x 16.7" x 0.3"
- Construction: triple-junction, Tefzel glazing, flex frame
- Warranty: within 10% of rated output for 3 yrs.
- Weight: 4.70 lb/2.14 kg

ORGANIZATIONS

CCAT (Campus Center for Appropriate Technology)
Humboldt State University, Arcata, CA

INTRODUCTION
By Bart Orlando

Pedal Power Perspective: What if the energy being exerter by people exercising in a health spa could be harnessed and used to generate electricity or run mechanical devices? Would it be possible to actually convert health clubs into human power plants? Would it make sense to pay people to exercise instead of charging them to use the exercise facilities? Seem far fetched? Wouldn't it be analogous to the way native - aboriginal people are rewarded by nature for walking while foraging or running while hunting? Shouldn't there be a reward for doing the right thing, especialy in a nation that spends almost 500 billion per year on chronic health care costs, most of which could be prevented by regular exercise. Also, how much of a dent could human powered devices make in our consumption of energy that is produced using toxic, deadly, polluting, non-renewable sources such as fossil fuels and nuclear power? How would improving the efficiency of the electrical devices we use help to make this a reality? These questions form the basis of our research into pedal power.

Bart Orlando - CCAT Volunteer: Bart Orlando began volunteering his expertise in pedal power at CCAT back in 1993, in answer to President Clinton's call for U.S. citizens to become community volunteers. Using a pedal powered generator to supply electricity to the PA system, he powered a speech by the Late David Brower at HSU. Since then, Bart has spent more then a decade guiding beginning HSU engineering students who assist him in making his designs of pedal powered equipment a reality. (Bart also has conducted research into the design of parabolic solar cookers at CCAT.) Bart earned a B.S. degree in pre-medical biology from UC Irvine, class of '82.

Pedal Power

Today, with the heavy use of automobiles combined with the burning of fossil fuels, increasing problems are affecting human health and climate change as a result of air pollution. Pedal power energy has been in use since the nineteenth century. Aside from transportation, pedal-power energy can be applied to a tremendous variety of jobs that contribute to less pollution and conserve energy in the home. Pedal power uses the most powerful muscles in the body: the quads, hamstrings, and calves, converting ninety-five percent of exertion into energy.

Many tools and appliances can be run directly with mechanical energy. With an old exercise bike, a generator, and a fan belt, human energy can be converted into Direct Current (DC) electricity. Some examples of tools that can be operated by pedal power are the table saw, band saw, meat grinder, wood carver, water pump, thresher and winnower, stone polisher, lathes, and pottery wheels. Appliances such as a juicer, grain mill, butter churn, and washing machine can also be used with pedal power. Here at CCAT, pedal power is used to run a blender, coffee grinder, TV/VCR, drill press, grinding wheel, and a multi-bicycle generator. You can exercise, save energy, and make a smoothie all at the same time!

ORGANIZATIONS

The Center for Appropriate Transportation is an excellent local resorce that would be able to build a custom trailor frame for the project and potentially extra welding and parts as needed...

CAT (Center for Appropriate Transportation)
Human Powered Machines, Eugene, OR

Human Powered Machines was established in 1991. Our primary interest is in relieving urban congestion by building load-carrying workbikes. We also produce many types of vehicles including recumbents, utility trailers, folding bikes, hand- powered vehicles and farm machines. The production of these vehicles integrates youth apprentices whenever possible. For more information call 541-343-5568.

HUMAN POWERED MACHINES has one basic belief: diversity of product. Just as a monoculture system impairs the health of agriculture, one basic bike frame form limits the potential of human-powered transportation.

Human Powered Machines is also unique with its work with youth. As a part of the Center for Appropriate Transport, HPM is the apprenticeship program where teenagers can acquire the diverse skills for a career in bicycle building.

HUMAN MACHINES POWERED

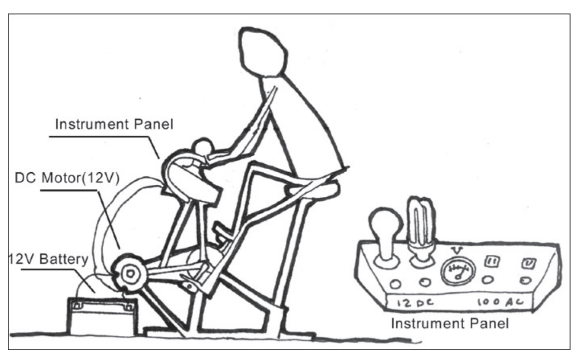
Pedal Power Organization
Vancouver, BC

PEDAL Power

The Pedal Works is a workshop to develop and build prototype pedal driven devices and promote the use of pedal power as an alternative energy. It is guided by the following goals;

* To develop pedal power technologies from recycled materials
* To empower others in the development of pedal power technologies
* To shift cultural perceptions of bicycles and their applications

What we do in practice...
We develop pedal driven devices for primarily agricultural/food processing applications (water pumps, grain mills, air compressors, blenders, juicers etc.). Check out the images, photos and more info coming soon...



http://www.pedalpower.org/works.html

PRECEDENT STUDIES

THE MULTIPLE BICYCLE POWERED GENERATOR

Designed and Built By Bart Orlando At CCAT This generator preceeded the Human Energy Coverter and was used one time at the Hog Farm Pignic in 1994. It was built at CCAT. Nine bicycles were held in place with straps and braces made of plumbing pipe fixtures. Arlo Hagler provided help with the electrical wiring. The rear wheel of each bike rested upon a friction drive "wheel" made from a fence post peeler core which was drilled through its center and cut in half so that it could be clamped to one of the long drive shafts, each coupled to one of two permanet magnet, 1800 rpm 24v generators. The generators (shown in the lower left corner above) were wired in series to summate their voltage. The final output voltage was 18v making it compatible with charging 12v battery banks. Diodes, (one way turn styles for electricity) prevent the battery bank from driving each generator as a motor. With hindsight, it would be better to fabricate individual exercise bike stands, each fitted with its own generator. Better yet, an after market kit for retrofitting ones bike with an electric motor assist could double as a generator if a custom bike stand was deployed to raise the rear wheel of the bike off the ground. That way people could ride their electric bikes to an event and then park them near the stage where they could provide electrical power. Most of the energy used in conjunction with a concert event is consumed as the audience commutes there by car. Over 5,000 people attended pignic concerts at the Hog Farm each year it was held.

THE PEDAL POWERED CONCERT GENERATOR

The pedal powered concert generator was designed by Bart Orlando and built with the assistance of HSU students, Ion Mion and Micah Gustafson.

24v, 800rpm permanent magnet generators were bolted to the side of a trailer used to tow the system to events. Each bike and generator was isolated from the others using a one way blocking diode. This allowed each person to pedal at their own pace and prevented the generators from drawing electricity from the battery bank, causing them to function as motors.

The powered generator powered the anti war protest on the Arcata Plaza in 2002 - 2003.

Real Goods Generators

In 1995 Jon Schaffer, the president of Real Goods, approached Bart Orlando at the Hog Farm Pignic and asked if a pedal powered generator like the HEC could be built for display at the Solar Living Center in Hopland , California. When asked how much it would cost, Bart responded that he would build it in exchange for vegetables. Before work began on that project, Real Goods commissioned Bart to build a pedal powered tv/vcr. They paid Bart $1,000.00 in advance. This, Bart's first attemp at a pedal powered tv/vcr failed. To make up for that, Bart agreed to build the system (shown above) for just the cost of materials (~ $ 12,000.00). Bart worked on this project for close to a year. Bart would stop by when traveling to San Francisco on buisness trips and work on it for a few days at a time. The original design of the system was made by Bart. Steve Harmon, of the Solar Living Center built the wooden platform and rewired the system to meet legal safty codes. This system charged a 12v battery bank which powered a sine wave inverter that supplied electricity to the bass applifiers for Merle Sauders and Doctor Loco at the 2001 Sol Fest. It is now on display next to the straw bale retail store building at the Solar Living Center. It is Bart's hope that one day each of the bikes will be connected up to a varity of electrical appliances in an interactive display which does more than simply charge a battery bank.

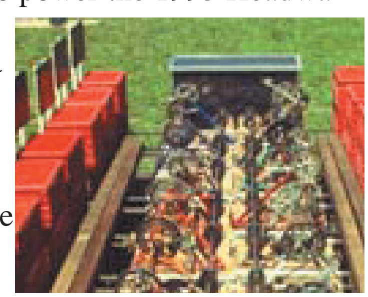
PRECEDENT STUDIES

THE PEDAL POWERED
BATTERY CHARGER

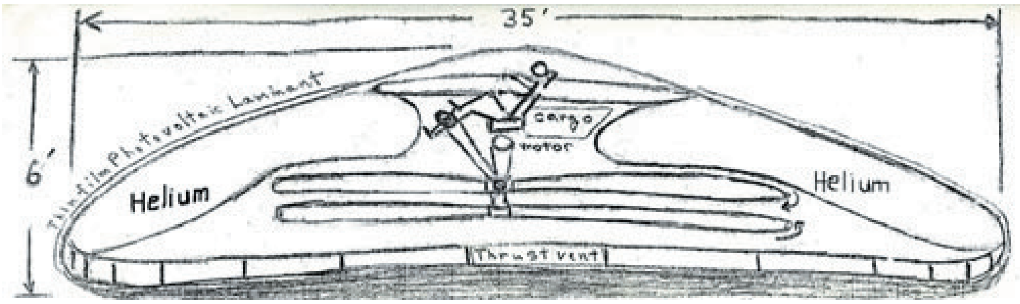
Designed and Built By Bart Orlando With theAssistance of HSU Students At CCAT

The pedal powered battery charger was designed and built by Bart Orlando at CCAT in 1996. It can be used to charge a 12v battery. The system consists of an exercise bike placed upon a pedistle as shown in the photo below. A fanbelt raps around the outer circumference of a 40lb - 16" flywheel and passes through a slot in the top of the pedistle. It then raps around a 2.5" pulley on a 1800rpm permanent magnet 24dc generator, mounted on the underside of the pedisle. When the exercise bike is pedaled at ~ 80 rpm, the generator spins at about half its rated rpm (~900 rpm), producing about half its rated voltage output (~15 volts). The faster you pedal, the higher the generators voltage output and the faster the battery charges. A diode is placed between the generator and the battery to prevent electricity from flowing back from the battery to the generator. If the diode was not used, the generator would draw electricity from the battery and function as a motor. A volt meter and amp meter are substituted for the mph gauge and effort gauge that come with the original exercise bike. The system was used to match the load of a 200 audio watt alpine car stereo amplifier driving a 200 audio-watt JBL speaker cabinet. The pedal powered PA system was used during open mike sessions on the HSU Quad for crowds of up to 400 people. It requires very little effort to pedal when used to power that PA setup. This charger is best suited for charging batteries under 100 amp hours. However, in 1998 class credit was offerred to HSU students enrolled in a physical education exercise class for helping to charge CCAT's 2,000ah battery bank by pedaling one of the five pedal powered generators at CCAT instead of the life cycles in the university's weight room.

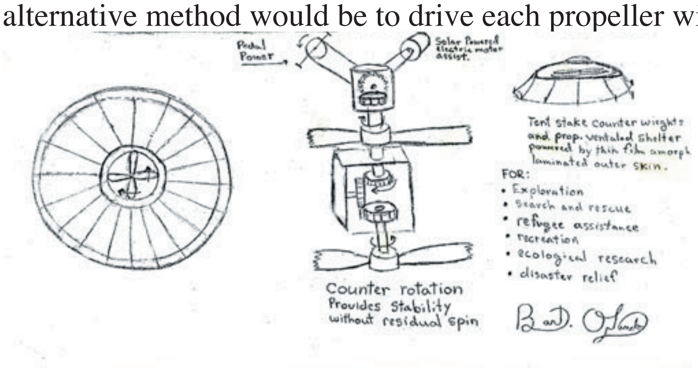
The Human Energy Converter (H.E.C.), a pedal powered electric generator that harnessed the pedaling effort of 14 people at one time. The H.E.C. was capable of sustaining a 1kw output at 24v. . It was used at rock concerts to help power such musicians as Bob Weir, Richie Havens, Merle Saunders, Big Brother and the Holding Company, John Trudell, Zero, Steve Kimock, Clan Dycan, Scott Huckelby and others. It was also used to power the 1995 Headwaters Forest protest/demonstration, as well as community events on the Arcata Plaza. It was featured at the Hog Farm Pignic and The Whole Earth Festival. The H.E.C. was built by Bart Orlando and Todd King, with technical assistance by Mark Muller.



PEDAL DREAMS



This is a diagram of a human powered airship. It is shaped like a frisbee and so can be considered a lifting body. The lenticular/parabolic shape of the airship is very aerodynamic and has a low crossectional surface area, reducing the effects of cross-winds. The weight of the vehical, pilot, passenger and cargo is balanced by internal chambers filled with bouyant helium gas, rendering the vehical almost lighter than air. The net weight of the vehical is countered by lift provided by two counter rotating 10 ft diameter propellers. A mechanical transmision, shown in the diagram above, is used to reverse the direction of one of the propellers. Counter rotation cancels out residual spin and eliminates the need for a tail rotor, while providing angular momentum for stability. An alternative method would be to drive each propeller with its own electric permanent magnet motor, each motor



being wired in reverse polarity with respect to the other. The pilot would pedal an electric genterator to supply electricity to the motors rather than pedal powereing a chain driven transmission. The counter rotating propellers are powered by a combination of human pedal power and an electric motor which is supplied with electricity by a thin film photovoltaic fabric laminated to the outer body of the inflated airship (made of the same material used in the fabrication of blimp envelopes). Within 25 years it may be possible to substitute a lighter/stronger material made of pure carbon Fullerene. It is 100 times stronger than steal, lite as foam and theorized to be so stable that it is capable of self sealing when punctured. The fact that the airship is inflated means that in effect, the pilot is surrounded by an exterior airbag, capable of cushioning collisions. The helium filled chambers are baffled in case of punctures. This vehical would be capable of flying at an altitude of 3,000 meters (~ 10,000 ft).

However, most flying would be done at about 3 meters (~ 10 ft.) above the ground to take full advantage of an energy saving phenomenon of areodynamics known as the gound effect. The design of this vehicle would also inable it to hover at any altitude within its altitude range. Since this vehicle combines the low flying techiques of the Northern Harrier and the Hovering technique of the White Tailed Kite, It could called a KARRIER, (kite + harrier = karrier). Steering is accomplished through banking (using fluid hydrolics to shift wieght from side to side or back and forth) and thrust vectoring (via air vents along the side of the airship which direct air from the propellers). The airship would be capable landing on water. If on land, counter weight tent stakes (driven into the ground) and attached to guide lines would render the vehical lighter than air and capable of functioning as the roof of a bouyant shelter from rain or the sun on a hot day. While in "shelter mode" the guide lines could support a tent fly and the solar powered propellers could provide ventilation. One such airship could shelter almost a hundred people if used in a rescue mission. An armada of such vehicals could be used to assist refugees fleeing a disaster area, a war zone or genocide. Larger airships, known as cargo lifters, would be capable of airlifting relief supplies directly where needed without the need of roads, airports or even......permission... by flying low under the radar and using cloud cover to prevent detection during their initial approach. When traveling along established routes, the airship could be tethered to a steel cable via a frictionless permament magnet collar so as not to be blown off course. It would be analogous to a buoyant gondola moving along a stationary cable.

GLOSSARY

Amperage - (Amps) This is a measure of the “volume” of electricity being used by an appliance or being generated while charging a battery. Amperage also goes by the name of current. If you think of electricity moving through a wire as being analogous to water moving through a pipe, then current is analogous to the volume of water moving through the pipe. A flow meter is used to measure the volume of water being used and amp meter is used in similiar way to measure the volume of electricity moving through the wire. DC amp meters are traditionally wired in along the positive line. Caution - do not attach negative and positive wires to the amp meter at the same time. DC Amp meters are single polarity.

Amp-hour - This is a measure of the capacity of a battery. A 100ah battery can supply 1 amp for 100 hours or 100 amps for 1 hour.The amp-hour is also a measure of the volume of electricity that an appliance uses per unit time. If you power an appliance by supplying it with 4 amps for 1 hour then it has used 4ah.

Battery Bank - Consists of one or more deep cycle batteries. They can be lead-acid (wet-cell, sealed gell-cell or marine) batteries, nickle-metal hydride (no memory and no toxic materials) or lithium-ion (similiar to those in lap top computers.... no memory and four times the capacity). Lead -acid batteries are 98% recyclable, although there are health issues concerned with lead contamination of battery factory workers. A good rule of thumb with which to size the battery bank is 50ah/pedaler. Sealed gell-cell lead acid batteries require a charge controller to limit the top battery voltage reached while pedaling to 13.8v so that you don’t boil off the non-replaceble electrolyte gell.

Converter - A converter is an electrical devise used to decrease the voltage of dc electricity from a starting voltage of up to 18v down to 12v, 9v or 6v depending on what voltage the devise you are powering... ie....a 9v portable cd player.

Diode - The diodes used in pedal powered electrical devices can be thought of as a one-way turn-style or a one-way “valve” which controls the direction in which electricity flows. For our applications it will be used to prevent electricity from flowing from a battery back to the permanent magnet generator/motor while allowing electricity to flow from the generator to the battery.
Diodes can be purchased at industrial - electrical supply shops. Diodes are rated according to their upper limits of voltage and amperage they can tolerate. Triple the maximum voltage and amperature that will be generated to give your system grace room.

Fanbelt - Fan belts are used to convey mechanical power form the exercise bike to the device being pedal powered. The fanbelts or v-belts can be purchased at hardwhere stores and auto supply stores. To choose the correct size belt, wrap a piece of string around the exercise bike flywheel and the generator pulley at the same time. Then use a tape measure to determine its length.

Flywheel - The flywheel is usually a lage diameter, heavy wheel that spins in place as you pedal the exercise bike. It functions both to smooth out the pedaling sensation and as a pulley with which to drive a fanbelt. Some flywheels are fabricated in a way that provides a space for the belt along its outer circumference. This space can be modified to provide better grip to minimize belt slipping. One way is to adhere “no-slip tape” used on the steps of swimming tools. The other way is to have a licensed machinist use a lathe to cut a goove along the outer edge of the flywheel which fits the shape of the v - belt, turning the flywheel into a hybrid pulley.

Freewheel - The freewheel is a device that allows the flywheel to spin freely while permitting you to stop pedaling at anytime. Some exercise bike flywheels come with freewheels built into the small drive sprocket on the side. Freewheels add a degree of safty in case your feet slip off the pedals. Without a freewheel, the pedals will come around again and hit the back of your ankles.

Fuse - When using a battery a 25 amp fuse should be wired directly to the positive terminal in such a way that all electricity flowing to or from the battery must pass though the fuse. If your electrical wiring developes a short, the fuse blow, preventing the flow of electricity and a possible fire.

Generator - The type of generator used in pedal power applications is referred to as a permanent magnet dc motor. If you mechanicly drive the pm motor it functions as a dc generator. The permanent magnet motor gets its name from the fact that uses real magnets (similiar to kitchen magnets) to create an internal magnet field necessary for making electricity. These generators can be obtained, with relatively low operating rpms. For pedal power applications, I recommend generators with rpm ratings of between 500 to 1000 rpm. Car generators and altenators use electromagnets which create a magnet field but to do this 1/4 of your pedal power is diverted to this purpose. These generators and altenators are usually designed to run at thousands of rpms (much to fast for pedal power applications).

Inverter - An inverter is a portable, battery powered, 110v AC electrical outlet. It takes DC electricity from a battery and changes it into AC electricity like that found in a wall socket. Inverters are divided into sine-wave and modified sine-wave types. Sine-wave inverters are intended for powerering computers, tvs, radios, recording equipment, guitar ampifiers etc. Modified - sine wave inverters are intended for powering tools like hand drills, circular saws. Sine wave inverters can also be used to power tools and motorized appliances. Inverters are catagorized by the voltage of the battery they are powered by (12v, 24v, 36v, 48v) and by the maximum power output they can sustain (150w, 500w, 1000w, 4000w). Inverters only run off of solar panels or batteries. They cannot run directly off of a pedal powered generator unless you can come up with a way to stabilize the fluctuationg battery voltage. (Hint - batteries work well for stabilizing voltage). I have heard rumers of attemps to use voltage regulators and capacitors for this purpose but I have yet to see a demonstration.

Power - Power is a measure of electricity that takes into consideration both voltage and amperage at the same time. POWER = VOLTS x AMPS. Power is measured in watts. It is also expressed as horse-power (hp). 1hp = 746 watts. To gain an intuitive understanding of how power, voltage and amperage relate it is useful to use the analogy of a stream of flowing water. If you happened to find yourself in a situationin in which you had to decide if you could safely cross a stream, you would want to consider both the volume of water (depth and width) and the speed at which the water was traveling which depends on the steepness of the slope down which the water is traveling. The volume of water is analogous to amperage and the slope of the grade down which the water travels is analogous to voltage. A pond or lake is analogous to electricity with low voltage. A waterfall is analogous to electricity with high voltage. A single falling drop of water is analogous to electricity with high voltage but low amperage. Niagra Falls would be analogous toelectricity having both high voltage and high amperage. Niagra Falls is very powerful.

Pulley - The pulley is the part that the fan-belt wraps around. A pulley is measured by its outside diameter (o.d.)and the diameter of its inside bore (i.d.). The o.d. determines how fast the pulley spins. A small pulley on a generator will spin faster than a large pulley. The output voltage of a pedal powered generator can be lowered by increasing the size of its drive pulley and visa-versa. The i.d. is determined by the diameter of the drive shaft the pulley is to fit on.

Resistance - This is a measure of the ease with which electricity moves through a wire. Resistance causes electrical energy to be dissipated as heat instead of being channeled into useful work. Resistance can be minimized by using large gauge stranded electrical wire (10 gauge instead of 16 gauge and stranded wire instead of solid wire). Electricity moves along the surface of a wire. Therefore, the more surface area a wire has ...... ie...... more thin strands braided into one wire...... the less of a traffic jam those little electrons incounter or in other words..... less resistance.

Sprocket - The sprocket is the pointy thing that a bike chain wraps around. Sprockets are measured by the number of teeth they have, their width (for wider chains) and their pitch (spacing of teeth).

Voltage - Voltage can be understood by using an analogy of water moving through a water pipe. Voltage is analogous to the water presure in the pipe.