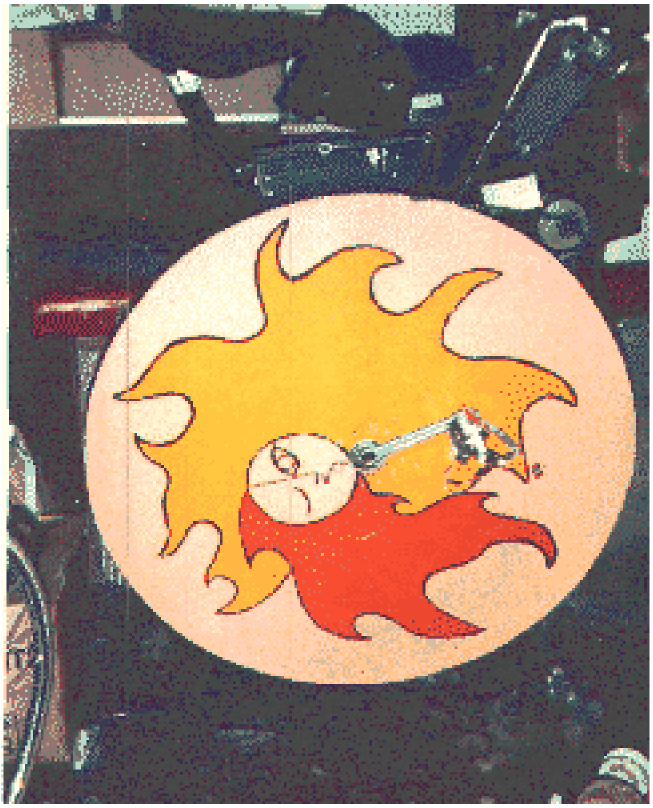


Pedal Powered Generator

A 36" particle board disk with a groove routed in the edge serves as the flywheel and crankshaft for the permanent magnet 36 volt DC motor (1 2) seen at the upper right edge of the device. A small-pitch chain provides the power transfer system. The groove around the outer edge is lined with "rim strips" - thin rubber straps that prevented the chain from slipping and digging into the particle board. They are standard bicycle parts. The motor was obtained around 1985 from Northern Hydraulic, now known as Northern Tool and Equipment Company.

The bottom frame is welded steel plate and channel, the crankset is an American Schwinn ball bearing set, a cotterless crank conversion spindle, alloy cranks and cheap pedals with toe clips.

The crankset has a steel chainwheel on it. I drilled some larger holes in the chainwheel and bolted the particle board disk to it. It was strong enough (fine Schwinn steel!) to hold the weight of the particle board disk and run true. I routed an oblong hole through the particleboard disk for the "arm" of the crankset.

The seatpost and handlebar tube are standard galvanized water pipe. The generator/motor is mounted on a piece of 3/4 plywood visible in the motor pictures seen above, which is then bolted to the water-pipe frame.

The particle board disk is a key feature of this unit. The weight of the disk serves as an excellent flywheel. Human legs and pedals create an extremely "peaky" torque curve, resulting in jerky motion and lots of stress on parts. The flywheel smoothes this all out by absorbing part of the energy on the power stroke, lowering peak torque, and releasing it on the "dead" part of the stroke, creating torque where human legs/pedals cannot generate any. Another thing to remember is that human legs do not like extreme stress. The flywheel allows the human to avoid having to generate extreme pressure during the power stroke just to make it past the "dead" spots. Many "bicycle converters" lack the flywheel characteristic because tires/rims are designed to be so light.

Noisy but extremely efficient, I have powered 12V **CHAIN SAWS** directly (yes, while someone else cut wood with them) with this unit.(1) Pedaling position was similar to a bicycle. The seat is barely visible at the upper left of the photo, and the handlebars (dropped, as on a ten speed road bike) are at the upper right.

Burst output: 25 amps at 17 volts (425 Watts)

30 minute average output (back when I was in shape) 150 Watts

Accessories:

A drill chuck threaded into the end of the motor shaft provided power for a flexible shaft drive. Drilling 1/2" holes through 2x4 fir with this arrangement was easy. The flex-shaft was rated at 1/2 HP (a commercial unit, about 3/4 in. thick - not a "dremel" type!!) and I was still worried that the torque would be too much for it.

For immediate electrical use, cigarette lighter outlets provided ready access to the juice. I even had a small 12v toaster oven, and pedaled my bagels to toast more than once. For storage I would charge a 12v 100Ah fork-lift battery. I could approximate the output of a 10 amp battery charger.

Be careful - I burned out several expensive 12v halogen bulbs powering them directly. I had no voltage control and exuberant pedaling would fry the bulbs in short order. When the storage battery was connected, this was less of a problem because the bettery tended to even out the voltage, but sprinting would still raise the voltage to the danger level.

At one point a ball-bearing 3600 GPH pump was substituted for the generator, resulting in amazing water pumping capacity. The suction from the pump was strong enough to collapse the heavy wall 1 inch vinyl tubing used for the intake (radiator hose would have been better, with the wire reinforcement) and the output shot a stream of water about 25 feet across the street. A 5 gallon bucket was emptied using this pump in less than half the time it took a garden hose to fill it. I believe the pump was driven to capacity (1 gallon per seconds, emptying the bucket in five seconds) in sprints.

Instrumentation consisted of a voltmeter and an ammeter, which together provided me with state of battery charge, output watts and somewhat of a "speedometer." The math was easy: **VOLTS x AMPS =**

WATTS. A 50 amp silicon stud diode mounted to a four inch square piece of aluminum sheet metal prevented reverse current flows, and became satisfyingly warm after long sprints (it is mounted in the center of the aluminum plate visible in the first motor picture). For top efficiency (and safety), a switch was also installed to completely isolate the diode and motor/generator from the battery.

I never had a chance to determine how efficient the unit was in converting mechanical energy to electrical energy, but I believe it was probably quite good. When running, only 4 ball bearings were turning, the only high-speed part was the armature of the motor, and I know from research that chains can be as high as 97% efficient in power transfer. The permag motor was probably better then average at power generation, because it was designed to be efficient as a motor. In "reverse" tests, with the motor driving the unit with no load, the power consumed was less than an amp at 12 volts. This is negligible, and much of it was resistance loss in the motor windings, since the motor drew half an amp with no load connected to it.

Status: The device outlasted me. I still have the motor and flex-shaft, but several job-related moves finally forced me to dismantle the unit.

Future: There are many other possibilities that I can think of for this device. The efficiency and variable speed of the output are two features that can be exploited. Here are some other devices that could be powered by the basic unit:

- Pedal powered backup generator for solar electric systems. With the newly available white LED as a light source, a few minutes of pedaling would be enough to create hours of light.
- Pedal powered washing machine (this would be a tremendous workout, especially with the spin/sprint at the end!)
- Pedal powered clothes dryer (when combined with a simple solar hot-air collector, the pedals would tumble the clothes and move the air)
- Pedal powered whole-house ventilation fan (15 minutes in the evening to cool off an entire house)
- Pedal powered watering system when combined with a cistern to store rainwater
- Pedal powered whole-house (central) vacuum cleaner - requires two people, of course
- Pedal powered air compressor (compressing air takes a LOT of power, and is not very efficient. This would work for small jobs only, like staple guns, caulking guns, small hand tools - no jackhammers!!)
- Pedal powered offset printing press, sewing machine (an ancient idea), hand tools (grinder, buffer, drill, reciprocating saw, lathe), mulch grinder

Basically, any device that was hand cranked, foot-powered, or powered by a fractional horsepower electric motor could potentially be converted to pedal power.

Also note, if the base unit is being used to power an auxiliary device instead of producing electricity, adding a solar panel will result in additional power from the motor! That means whatever device you are powering would receive the **combined** power of the human pedaler and the solar panel. This combination makes the best of both power sources, as efficiency would be very high, because the solar output would not suffer the losses of being stored and then extracted from a battery. Charging a battery and then extracting the same power is less than 80% efficient, and can be much worse. Direct utilization captures that wasted power.

Finally, keep in mind that a **tandem** setup for the pedals, with the pedals out-of-phase, doubles the power and smoothes out the power flow. Only one "flywheel" is needed, so this enhancement needs only a simple pedal/seat addition to the basic unit. With out-of-phase pedals, peak torque is not increased, so other parts of the system are not stressed. The torque curve for a complete revolution of the flywheel simply smoothes out, while RPM's stay constant, resulting in twice the power.

Over time, a number of questions have asked about the information on the page. Here are some Frequently Asked Questions and answers/opinions:

Do you have plans available?

> No. I am working on drawings of this generator and a recumbent version, but they are not yet available.

Would a car alternator work better for generating power?

> No. Most automotive alternators have one ball/one sleeve bearing, a built-in power-robbing cooling fan, and they require external power to excite them at low-to moderate RPM's. They have never been designed with efficiency in mind, since they were attached to monstrous motors capable of producing orders of magnitude more power than the alternator required. They actually produce AC power, which subsequently must be rectified to DC to charge batteries. This step causes significant power loss in the diodes (around 5%). As I noted above, I ran power output around the diode and directly into the battery to avoid this loss. In addition, alternators are designed to run at extremely high RPM's (alternator pulleys are smaller than the driving pulley on the engine, meaning the alternator turns FASTER than the car engine. Look at your tachometer reading and double it. Whew!), and do not produce usable power until they are rotating quite rapidly, requiring high ratio's of step-up from your pedals. A well-designed permanent-magnet ball-bearing motor, preferable one designed to squeeze every last bit of power out of a set of batteries, will beat an automotive alternator in efficiency.

Wouldn't gears help generate more power? And what about belts instead of chains?

Maybe. Humans can only pedal through a small speed range, about 40-120 RPM's. Below that you can strain your joints, and above that efficiency falls off. There is a "magic" speed (different for every human being) at which they can generate maximum power. The proper gear ratio enables the human to pedal at that speed. You may have noticed, though, that a human's maximum power output can change quickly from fatigue, and slowly from changes in conditioning and age. The magic speed is always changing, so having a few closely-spaced "gears" or ratios may enable a better match of human to generator. No matter what, though, **gears don't create energy, they waste energy**, so having fewer of them is always better. The same goes for bearings, even ball bearings. The pedal-power generator described on this page had very few of both, so it was very efficient.

Regarding belts, the transfer efficiency of most belts is less than chains. This is mostly due to flexing energy loss within the belt material and friction losses at the engagement points between the belt and the pulleys. Belts also work best when transferring low torque at high speed (the opposite of what a pair of legs produce!) which is why you do not see them on bicycles, for example. There may be some exotic, thin, high strength belts that could approach the efficiency of chains with the right design. For example, the "serpentine" belts used in modern automobile engines are much more efficient than the old "V-belts" from the past. Belts rely on friction to transfer power. Friction is bad. The best feature of belts is that they are *quiet*, so I can't say to avoid them completely. If you decide to use a belt to transfer power, use the thinnest, strongest belt you can find, and place only enough tension on it to keep it from slipping during use. I do not know whether equivalent "toothed" and "grooved" belts are equally efficient, but I believe the toothed belt has slightly lower friction losses. If I can ever find some real research data on the web I will link it in here.

How much power can one human being create?

This is an opinion. I used to be a competitive swimmer, and for a number of years, I worked out 6 hours a day, swimming approximately 13 miles. Yes, 13 miles a day. If you pedaled that hard for that long you might be able to run one ordinary refrigerator for 24 hours. To make any kind of significant contribution to your energy supply, you must use the most efficient devices you possibly can. For example, a small refrigerator designed to be powered by solar power would be much more practical. A rule of thumb: if the device was designed to be powered by batteries, even BIG batteries, you might be able to keep up with it.

If your electric bill shows KWH (kilowatt-hours), take the number, multiply by 4 (assuming you can crank out 250 watts for an hour) and that is how many hours you will have to be in the saddle to create the same amout of power. Sorry, it can be depressing. The moral: **Using less power is as important, if not more important, than making more.**

There are numerous sources of efficient appliances on the web. One place I like to shop is Real Goods, and of course I have spent time inventing my own efficient devices. The white LED light I built shows how technology can create new solutions to increase efficiency. Pedaling for an hour at the 200 watt pace, with 80% efficiency of generation/storage/extraction, would create enough energy to run that light for **320 hours!!!**

Can I generate 110V? Can I run my electric meter backwards?

I don't recommend this! If someone were to replace the permanent magnet DC motor in a pedal generator (such as the one on this page) with a 1/4 to 1/2 horsepower 110V **induction** motor and pedal that it would result in an amazing thing. If the motor was hooked to the power lines and it was "pedaled faster than it wanted to go", it would start generating 110V alternating current. Beautiful sine wave AC. If it was creating more energy than your clocks, refrigerator, all those little square black power supplies you have plugged in around the house, your lights, and that 300 watt stereo you are listening to while you pedal all use together, your electric meter would slowly creep backwards. However, that same motor would generate exactly **0** power if it is not plugged in to 110V AC.

For very light duty "off the grid" use of 110V AC, you can try pedaling your 12V DC generator into a large battery and hooking up an inverter (12V DC - 110V AC) to get some pretty decent 110V power. You CAN'T use this method to "run your meter backwards"!!!! In general, plan on being able to pedal about 100-250 watts for half an hour or so.

For efficiency, however, **you are much better off producing 12V DC for a 12V DC TV (for example) than you are producing 12V DC to charge a battery to run an inverter to power a 110V AC TV**. The UPS (uninterruptable power supply) for my website computer system can power the computer for about five minutes. The same battery (12v 1.5 AH) would power my laptop computer for about 45 minutes. Everything (efficiency-wise) works FOR you when the device being powered is designed to be efficient (12V DC) and AGAINST you when it is not (110V AC).

How big should my batteries be?

If you are considering building a similar system, plan on using two batteries, and a simple switch which allows you to use one while charging the other. Flip this switch right before you begin charging to ensure that you are charging the battery with the lowest charge (the one most recently used). Also be sure to use a battery that is roughly equal to ten or twenty times your power output for a charging session. For example, if you crank out ten amps for an hour each time you charge, choose a 100-200 amp hour battery. Larger batteries will simply loose charge through self-discharge faster, resulting is less efficiency for your system and more useless work for you.

Remember:

1. The **most efficient** way to use the power you create is not to create electricity at all, but to power your (pump, fan, hoist, winch, drill press, grinder, sewing machine, etc.) directly.
2. The **second most efficient** way to use the power is to pedal a generator to electrically power your (television, radio, floodlight, chain saw, laptop computer) directly, with no battery. Be careful about voltage, or use a good regulator.
3. The **least efficient** way to use your power is to generate electricity and store it in a battery, then extract it from the battery to power some device. Avoid this method in favor of methods 1 and 2!!

For more information, read this excellent writeup giving details on a different design based on a bicycle and rollers. .

(1) Three things about the chain saw. One, I was in great shape and probably was generating over one horsepower in the sprint. Two, the branch/log was about three inches in diameter - not anything near the 14 inch bar length. And three, the saw was a 12 volt saw, so it was designed to be efficient. The literature from the saw said that the motor was a permanent magnet Bosch electric winch motor, which was a good match for the maximum output of the pedal generator. It was great to see the chips fly!

Back To: [David Butcher's Personal Page]
This page is hosted by The WEBworks * Copyright 1994, All Rights Reserved

David Butcher's Micro Solar Energy System

I have always been a solar energy nut. I finally have a small photovoltaic system up and running, generating 12 volt power (though in very small amounts) and providing me with a way to learn what I need to know before I expand to a large scale "off the grid" system.

I began the small solar lighting system to light one dark hallway and my garage. Of course, things have progressed from there. Solar electric systems are easily expanded, and I started with a very small system. I had plans to expand it over time. Here is the chronology:

The project actually began in the 1970's when I begin building solar cell panels and teaching workshops on panel construction. Among the many small solar panels I built was a 12 volt, 1 amp panel built with single crystal 3 inch silicon cells. The panel had never really been put into service, but through all my travels I kept it with me, and I finally decided to celebrate the new millennium by permanently installing it and finding something useful to do with the power it generated.

The first installation consisted of a Trace C12 charge controller, two very small (4 AH at 6 volt) gell cell batteries and a white LED light of my own design.

The light has 6 white LED's, arranged in two circuits, with a fan switch which gives bank A, bank B and both banks with successive pulls of the cord. The light tube is free to rotate, giving the light the ability to be directed through a 180 degree arc. Power is 12v DC, and each bank of 3 LED's draws 20ma - yes, twenty milli-amps. The entire light, including switches, materials, LED's, screws to hook it to the roof and even the wire inside the light cost under $25 !!

The light is a prototype. I will construct a brighter version when the next set of LED's arrives. Here is a closeup of one end of the light to show the two-way pull switch.

It's not a twin tube 40 watt fluorescent shop light by any stretch, but it is impressive how much light can be produced by running only half a watt through these little solid state lamps.

I will create detailed plans if anyone is interested.

Mon Sep 04 17:31:21 PDT 2000

Well, the "micro" name may have to be dropped. I have added three more solar panels to the system. Here are the details:

1. I bought a small (250ma, 12v) panel on sale at Real Goods for $39 (regularly $69) and wired it in. It is weatherproof, has it's own blocking diode, and it is now mounted fairly high up on the eaves.
2. I took my oldest 12v panel, 30 200ma "satellite" cells assembled into a panel in 1982, and

mounted it in a clear skylight. This panel only produces about 15v instead of the usual 18v (36 cells is typical), so it is more valuable when there is a load on the system or when the batteries are fairly low.

3. About five years ago I bought 4 used solar panels for $75 each. In July I built a redwood frame (aluminum is sometimes referred to as "solid electricity" because of the amount of power (i.e. coal/oil/nuclear) required to produce it. Redwood is renewable.) to hold the panels. Everything went well, and I now have a 4 foot square panel. That is large enough to produce around 100 watts! The panel lives on the roof of the garage, and I use the power it generates to recharge everything inside the house on "Sunday" every week.

Now the system is starting to really produce some power! In fact, I found that the combination of small panels kept the batteries charged all week, running the LED lights I had in the hallway and in the kitchen, and I had enough power with the big panel to run a solar powered drip coffee maker on the weekend! Even after making coffee, there was power to spare.

I am now cleaning up the system and considering adding more lights in several places in the house. With 28AH of batteries and the panels I have, I can probably have two or three times as many LED lights as I have now. I will be building more lights soon, and I will also create a diagram of the system to show how all the pieces fit together.

Sat Sep 16 23:06:50 PDT 2000

Today I made some progress on system reliability. I followed instructions from Home Power magazine, and built a battery desulfator circuit. This circuit pulses the batteries with high current, high frequency current which results in elimination of sulfate buildup. The circuit is small, and it looked easy to build. I have it working on an old 25AH Gell Cell battery that I bought new, never used, and is now severely sulfated. Something is definitely happening, as the charge current on the battery is gradually increasing from almost nothing (3 ma). I'll post the results here, but it may take several weeks to determine whether the battery can be saved.

Sat Nov 25 09:43:12 PST 2000

Big changes are taking place. The solar system has become a tangled mess of wires, inverters, alligator clips and cords. Today I will work on organization. I will present photographs later today showing how the different components fit together. To make a presentation, I have been attaching the components to one foot square ceramic tiles. While this will take up more space on the wall, it will also enable the system to be cleanly organized and modular.

Sun Feb 17 19:42:39 PST 2002

Wow. The time flies. I have had white LED's in our walk-in closet for almost a year. They are powered by three Ray-O-Vac D Alkaline rechargeable batteries, charged weekly using a small (140 watt) 12v to

120v inverter, and an Ray-O-Vac battery charger. The system has worked like a dream. I have a small microswitch (Radio Shack) on the door, and the LED's turn on automatically when the door is opened. 90% of the time my wife and I use this light source instead of turning on the two 40 watt florescent lighting fixtures. Fabulous!

Elsewhere in the house, I have created more LED "strip lights." Under the kitchen cabinets, I have three sets of three white LED's where I used to have 110v strip lights. These LED lights are wired (though the kitchen wall) to the 12 volt power source in the garage. A simple pull-switch turns them off and on. With these lights available, the 150 watt track lights in the kitchen are seldom turned on. Another big win for solar energy!

I have also created a 6 LED light fixture for the short hallway between our house and the garage. This simple fixture has two features. It is turned on by a microswitch, just like the closet lights, and it has several large capacitors (about .1 farad) in the circuit with the LED's, so the light does not turn off immediately! This allows me to walk out into the garage and then back after the door closes. The door closes automatically to comply with fire codes.

These projects have enabled us to "kill" a number of 120v grid powered lights. While the 120v lights are still available, the 12v solar LED lights are automatic, and they are almost always enough. Simple, easy, cheap, and hundreds of times less power-hungry than their 120v counterparts.

Mon Oct 28 18:39:58 PST 2002

Big changes! Since the last entry, my wife and I bought a house. In the process of moving, every solar system had to be taken apart. Little by little, I have been putting them back together. One of the systems I cannot live without is the under-counter lights in the kitchen. This time, as I built the system, I took some pictures of the process. I believe anyone could do what I did, and create similar lights. These lights are powered by rechargeable batteries, and the batteries are charged with solar electricity, so they are "off-grid." Here are the details.

Thu Nov 7 15:45:57 PST 2002

A strange thing happened today. It is raining, so I figured it would be a good day to clean up some of the wires on the Microsine Inverters (OK4 for you NKF fans). When I did my ususal "finger test" to see if they were warm (active), one was stone cold. Now I admit it was raining, and I did not expect much power to be generated, but the other one was noticeable warmer. I went inside and got my laptop computer, hooked it to the OK485 computer interface, and checked up on the inverters. Sure enough, one was putting out 15 watts and the other was at zero. Interestingly, the one at zero said that it could not read the "plug" voltage: 120 volts AC. After much fiddling, and switching wires around, and "rebooting" the inverter by unhooking it from both the 120 volt AC line and the 24 volt DC solar panel, I was ready to give up. Then I rememberd one of the old tricks I had learned back when I repaired computers for a living. I took a screwdriver, held onto the metal end, and whacked the inverter with the handle. It immediately fired up and began producing power. Sometimes the low-tech solution is the best solution. I have mailed NKF tech support for suggestions. It could be a cold solder joint, or some other problem. Whaterver is was, it is "fixed" for now.

David "Photons, not Neutrons" Butcher

Disclaimer

This information is provided in good faith but no warranty can be made for its accuracy. Follow these suggestions at your own risk! If you notice something incorrect or have any comments, or information to add to these pages, feel free to mail me.

First and Last Name:

Email (Optional):

Please enter any questions or suggestions you have in the area below:

To send your comments to David Butcher, press this button: Send Comments.

David Butcher
davidbu"at"www.los-gatos.ca.us
Tel (408) 978-5495
Los Gatos, California 95030

Bicycle Powered Generator

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 never tried.

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**

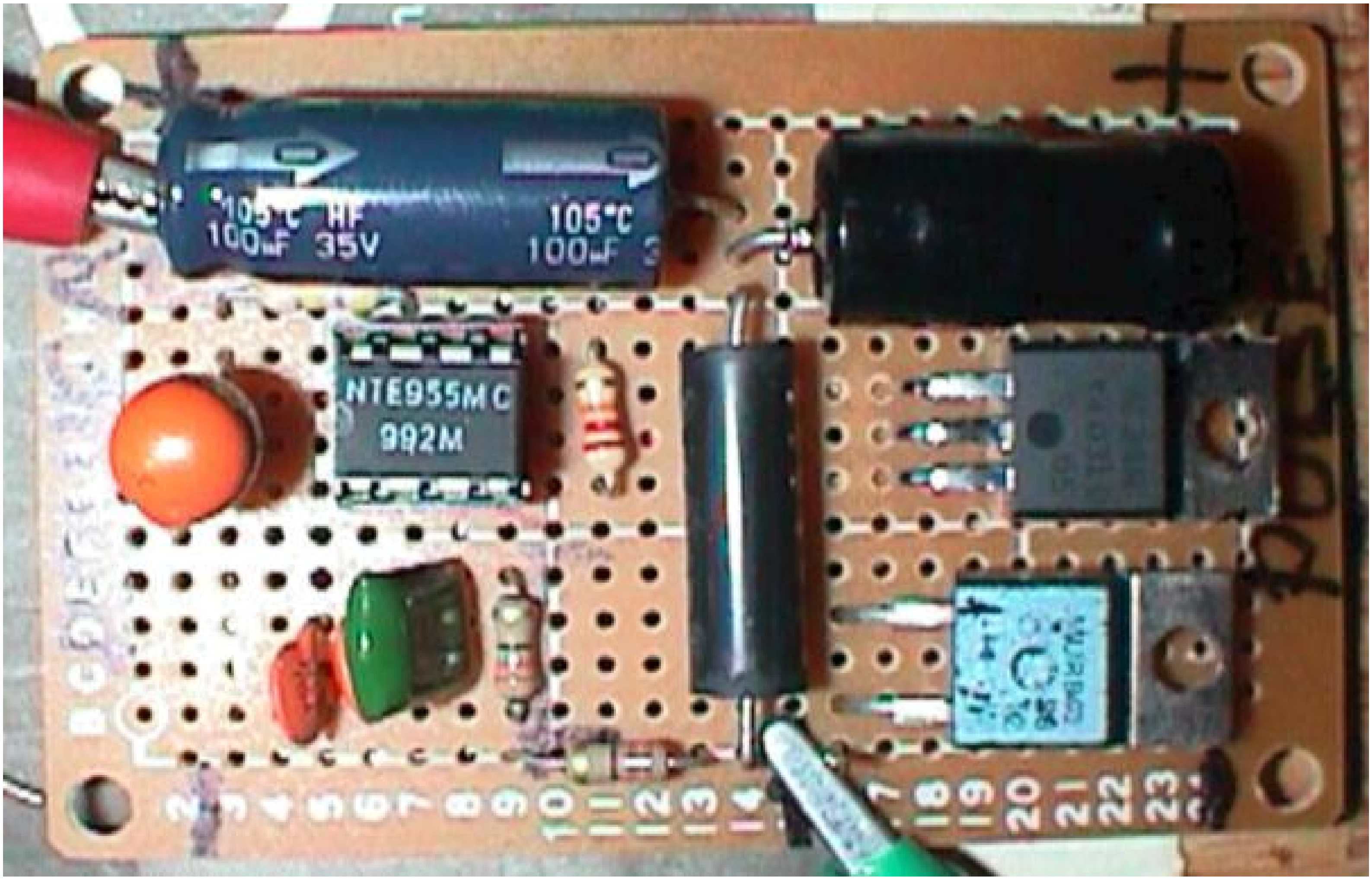
Battery Charging	Great	Able to push a continuous 4 to 6 amps into a 12 Volt automobile battery. The best setup was to put a rectifier diode in series with the generator output. This stopped the battery current from driving the generator backwards and enabled the rider to start pedaling without any initial 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.


105°C HF
100uF 35V
105°C
100uF
NTE955MC
992M

Micro Solar Energy System: Under Cabinet LED Light

As in many kitchens, we have lights under the cabinets to light the kitchen counters. These lights are powered by 110v (the grid) and are fluorescent. They are relatively efficient, but they are all wired to the same switch, and they all come on at once. They are too bright for the gentle "ambient light" my wife and I like to have in mornings and evenings, when we are just making coffee or drifting in and out of the kitchen to visit the sink or refrigerator. We wanted a light that was solar powered, efficient, based on white LED technology, and much less bright. With a little effort, we built one! This page is for the do-it-yourself solar light enthusiast. Anyone could build one of these lights! While it does not have to be solar powered, simply recharging the batteries from a solar panel is all it takes to keep the lights "off the grid." This project is an excellent starter project for a small solar system, and it would make an excellent school science fair project as well! Here are the details:

The light has 3 white LEDs, with a pull switch used to turn it on an off. The light body is free to rotate, giving the light the ability to be directed through a 180 degree arc. Power is 4.5v DC, and the 3 LED's draw 20ma - yes, twenty milli-amps. The entire light, including switches, materials, LED's, and even the wire connecting the batteries to the light the light cost under $25 !!

It's not as bright as the 40 watt fluorescent lights next to it by any stretch, but it is impressive how much light can be produced by running only one tenth of a watt through these little solid state lamps.

The LED lamps are powered by three Ray-O-Vac D Alkaline rechargeable batteries, charged weekly using a small (140 watt) 12v to 120v inverter powered by a solar panel and battery, and a Ray-O-Vac battery charger. The system has worked flawlessly. 90% of the time my wife and I use this light source instead of turning on the five 20 watt florescent lighting fixtures. In other words, we are using **1000 times less energy** to produce the light we need for many of the activities in the kitchen.

This single project enabled us to dramatically reduce the use of a number of 120v grid powered lights. While the 120v lights are still available, the solar LED lights are convenient, and they are almost always enough. They are simple, easy to build, cheap, and hundreds of times less power-hungry than their 120v counterparts.

Are you ready to build your light? Let's begin!

- Materials required:
  - Wooden dowel 36in./1 meter long, and 1/2in./1.25cm in diameter(1)
  - "D" Cell battery holders (sufficient for 3 cells)
  - White LED's (3 or more)
  - Pull chain switch (1)

    - Terminal block (1)
    - Small gauge wire, 2 conductor "zip cord" is ideal (6 feet/2 meters)
    - Fuse holder and 250ma fuse (1 each)
    - 50 Ohm 1/2 watt resistor (other values may be required, will be explained later)
    - Large cup hooks (2)
    - Electrical tape (36 in/90 cm)
    - Block of wood to hold parts (6in x 6in x 1/2 in, 15cm x 15 cm x 1cm)
- Tools required:
    - Small screwdriver
    - Drill - 3/8 inch bit
    - Soldering iron (25-30 watt)
    - Wire cutters, or "Xacto Knife" - any small sharp knife (gloves recommended)
    - Small wood or metal saw, if dowel needs to be trimmed for length
- Time required to assemble and install: 2-3 hours

1. Understanding the design, and theory of operation

   The design of the light is extremely simple. The light itself is constructed of a wooden dowel. The LED's are attached to the dowel, using electrical tape. One is attached in the middle, and the other two are attached at each end. The wire runs the length of the dowel. The dowel is then placed underneath the cabinet and suspended from the two cup hooks. That cup hooks should be fairly loose, allowing the dowel to be rotated. This will allow the light to be aimed in the most effective direction.

   The light is powered by three rechargeable D cell batteries. The LED's require 4.5 volts to operate. The three D cell batteries provide this when they are connected in series. The maximum current the LED's can tolerate on a long term basis is 20 ma. Three freshly charged D cells will drive more than that much current through the LED's, shortening the life of the LED's. To control this current, a resistor is inserted between the batteries and the light. For safety, a small fuse is also installed.

2. Choosing a location for the light

   The best place to install the light is in the work area that does not require bright light, but is frequently used. I usually set my light up close to appiliances I use early in the morning, such as the coffee maker. These lights are not really bright enough for complicated cooking tasks, but they might be enough for loading a dishwasher, and they are certainly bright enough to help you find the 'fridge!

3. Assembling the light

   After you have determined where the light will be, measure the length of the space and cut the dowel to fit, if necessary.

Now begin to wire the light by taping the wire down the length of the dowel. Flatten it out (no twists) so the conductoes do not "switch sides" as the wire travels down the dowel. Tape the wire to the dowel in three places: the middle, and both ends. Wrap the tape around the dowel an inch or soA from the ends of the dowel. The wire should end at the end of the dowel on one end, and the remaining wire should continue for several feet past the other end of the dowel.

Next prepare the wire for soldering on the LED's. Examine the wire closely. If it is "zip cord", it will have two conductors joined together by the insulation surrounding them. One of the two conductors will be identified in some manner. The wire will be a different color, or have a colored stripe on the insulation. This will be the "positive" wire. Each LED will be attached between the positive and negative wire. In the next step, you will cut through the insulation exposing the bare wire at each point that an LED will be attached, enabling the LED's to be soldered to the wire.

Beginning at the end of the dowel with the long piece of wire extending from it, cut into the center of the wire about one inch (closer to the middle of the dowel) from the electrical tape. Carefully pull the two individual wires apart until they are far enough apart to stick your finger comfortably between them. Do this step at each location you are planning on having an LED. At the other end of the dowel, simply separate the two wire for about 1/2 in. (1 cm.).

Take a moment to check your work before the next step. You should have a dowel that is the right length to fit easily in the space you have chosen. It should have a wire taped to it, with one end of the wire stopping right at the end of the dowel, and the other end extending past the end of the dowel by at least 1 foot (30 cm). The wire should be laying flat on the dowel, with no twists. At every place along the length of the wire where you are planning on attaching an LED, you should have cut through the insulation and separated the conductors a bit. There should be no bare wires at this point. Ready for the next step?

The conductors in the wire must be exposed so the LED's can be soldered onto them. The insulation must be cut away from the wire to allow this. There are two possible ways to accomplish this:

1. Cut the wire completely at each LED position, and strip the insulation off the cut ends.
2. Carefully "carve" the insulation away from one side of the wire, leaving the conductors intact. If you have patience, carve all the insulation away from 1/4 in (1 cm.) of the wire - both conductors.

If you choose option 1, your soldering job will be cleaner, but you may need three hands to hold everything while soldering. You will need to hold both ends of the wire, the LED, the soldering iron, and possibly the solder! If you have a helper, this is probably the better technique.

If you choose option 2, the wire itself will not be cut, so you will be able to hold the LED onto it with one hand and hold the soldering iron with the other hand. You can probably assemble the light without a helper if you choose option 2. One possible problem with this technique is that any remaining insulation on the back side of the wire (if you could not cut it completely away) will probably melt during the soldering, so the finished work may look a little messy.

At the end of the dowel where the wire stops, simply trim the insulation back 1/4 in. (1/2 cm.) so the bare wire is exposed.

It is time to prepares the LED's for soldering. Handle the LED's with care. If you happen to develop a sharge of static electricity, and touch a LED, it could be "zapped!" That means no petting the cat during this next activity!

LED's have two wires (also called "leads") coming out of the bottom, and lens on the top that focuses the light. Look closely at the leads - one is longer than the other! Not by much, but there definitely is a difference. The longer lead will be attached to the positive wire on the light, and the shorter lead will be attached to the negative wire.

Before soldering the LED's onto the wires, bend the leads on each LED to make the job easier. Bend the leads about 1/4 inch (.5 cm.) from the bottom of the led. bend them in opposite directions, intil they are at 90 degrees from their original position. You should be able to gently set the LED on to the wires you stripped, with each lead going to its respective wire. It won't say there, of course - that is what the solder is for. Don't bend the leads on all your LED's yet, or you will loose track of which lead is positive! Bend them one at a time, right before you are ready to solder them, and keep track of which lead is which.

4. Assembling the power source
5. Testing
6. Installing the switch
7. Installing the light and power source
8. Testing and troubleshooting
9. Maintenance

David "Photons, not Neutrons" Butcher

Disclaimer

This information is provided in good faith but no warranty can be made for its accuracy. Follow these suggestions at your own risk! If you notice something incorrect or have any comments, or information to