ENERGY SELF SUFFICIENCY NEWSLETTER

February 2005

Wind
Solar
Hydro
Biofuels
Off-Grid Living

Al Rutan

The Methane Man

This Issue Is Dedicated to Al's Memory and His Legacy

* Electricity 101
* Off-Grid Journal
* Human Powered Vehicles
* Passive Solar -- Sunspaces

A Rebel Wolf Energy Systems Publication

From The Editor's Laptop

by Larry D. Barr, Editor

I'm writing this early (0325) in the morning of 9 January 2005 and there's a big smile on my face. As of about 30 minutes ago, almost 6000 of you have downloaded the premiere issue of ESSN. That's a much greater response than I expected, and it's a great tribute, not only to the dedication of the renewable energy movement, but also to the members of all the groups on the net who've helped to spread the word. Our thanks to all of you.

Your comments on our efforts have been most complimentary and kind. We've had emails from as far away as Australia, Scotland and the Netherlands. And those are all a long way from North Central Texas. It's really gratifying to know that interest in our movement comes from around the world.

As we progress in our individual quests fo energy self sufficiency, I believe that we must also endeavor to spread the word about our beliefs. It's not enough to just buy a couple of PV panels, a wind generator, six Trojan T-105s, charge controllers, diversion loads and an inverter -- and then to snuggle down in our energy efficient house and pride ourselves on our achievment..

If we are to truly make a difference in this world, we must seize every opportunity to share with others our convictions regarding renewable energy and the imperative of its use in the world today. There are many people who are not uncaring, but are merely unaware. We can enlighten them. But first, we must make the decision to talk to them.

About a week ago, I was standing outside the building I work in, smoking a cigarette (one of my few vices) when my friend commented on a Dodge Diesel Dually driving by. "Nice truck," he said. "Sure would like to have one."

"Yeah, it's nice," I replied. "But is sure sucks up a lot of dead dinosaurs. Just imagine how much fuel, irreplaceable petroleum, would be saved if that pickup was running on biodiesel made from used fry oil. The pollution would drop like a bad habit and the driver could save a buck a gallon or better. Makes sense to me."

Steve's first reaction was along the lines of "What the hell are you talking about?" As I took the time (it didn't take long) to explain to him why I'd said that, I could see comprehension dawning on his face. As I finished he said, "You know, that makes a lot of sense, and it's something I'd never thought of before."

I can't promise you that he'll immediately be a full convert to our movement. But take my word for it, he's definitely thinking about common things in an uncommon way now. Because I simply took the initiative to mention renewable energy.

I know that all of us who are reading (or writing) Energy Self Sufficiency Newsletter are dedicated to disseminating information about our movement. But we must take every opportunity to tell folks why we feel the way we do. We have to speak up, not just to the press, but to the people we talk to every day.

The mainstream press is only interested in stories that are "newsworthy." And what qualifies as newsworthy for us doesn't necessarily make the trip for them. I believe that we can accomplish much more for the renewable energy movement by sharing our beliefs and our convictions with the people we talk to in ourdaily life.

Don't misunderstand. I'm not saying that we shouldn't let the press know when we have a newsworthy project or cause to talk about. But I am suggesting that we can do a lot of good and make a lot of progress by simply taking the initiative and mentioning renewable energy whenever the opportunity presents itself. So let's do what we can and spread the word every chance we get. ldb

Well, I'm Sure Glad That's Over

The Hosting Change Saga

by Larry D. Barr, Editor

Technologically, life got really bad about 2000 on Friday, 7 January. That's when all email traffic in and out of rebelwolf.com came to a screaming whoa (as we say here in Texas). All the efforts of my tech guru were for naught, and once we discovered that the problem was inherent in the email software of the hosting company, we had not choice but to change hosts.

That's never really a lot of fun, but it's possible to make it fairly painless. And, of course, our goal was to make the transition as seamless as possible. It's actually a simple process. Just load the website content onto the new server, change the DNS (domain name system) pointers to send requests to the new host's server and wait for 24-36 hours for the changes to propagate thoughout the World Wide Web. No problem, right??

Wrong! Not this time. After a fairly short waiting period, I could access the new site at work, but it took a little longer for the DNS server that send the Net to my house to get the message. Then it came in. But the email still hadn't come in. That, as you remember, is the problem that started the whole fiasco to start with.

It turned out that the new company had their own set of flaws and it took about 4 days before I finally figured out that I should have gone with the company that Steve Spence recommended to start with. That's what I get for shopping price instead of trusting the word of a knowledgable friend. We're squared away now, with ICDSoft, and all is well. Everything works and we're back in business. Thanks, Steve.

Thank you for sticking with us through this tech mess. I'm sure that some of you had your emails to us bounced back, and probably wondered what happened to ESSN. Well, now you know. We were the victims of Silicon Alzheimer's or something similar. But we're better now and ready to read your re-sent emails. ldb

In Memoriam

Al Rutan

"The Methane Man"

The renewable energy community lost a true pioneer on 9 January 2005, and those who knew Al Rutan lost a true friend. Al passed on while staying at the home of a friend and doing what he loved. Designing and fabricating a methane digester plant. Al's dedication to our movement of renewable energy and energy self sufficiency was technically astute, and tempered with a true concern for the animals involved in the production process. Al knew instinctively and believed deeply that we must always consider the well-being of all the creatures of Mother Earth in our quest for energy independence. His concern for the animals who walk the Earth with us is only part of Al's legacy.

A former schoolteacher, Al never lost his love and desire for sharing his knowledge and experience with others who wanted to learn about methane and energy self sufficiency. Through his website and his writings, most recently in this publication, Al Rutan shared the message of energy self sufficiency with all who sought his knowledge.

I will always regret that I never met Al personally, but I will always be grateful that I had the opportunity to know him though our emails, and to work with him, albeit for much too short a time, in the pages of this magazine. Al, for your knowledge and skill, your dedication and compassion, your love of renewable energy, your willingness to share and, most of all, your friendship. we thank you. You will be eternally missed. Rest In Peace, my friend. ldb

By His Friends

Farewells From The Renewable Energy Family

My dear friend Al,
Today I received an email from you. But it was written by your friend. The email informed that you already left the earth and now you are in heaven. I am really sorry to have not written to you frequently. I have never thought that you left us so suddenly. You always said that you would visit South Korea to complete your energy recycling project in South Korea and to meet your friends (including me) in South Korea. But sadly you passed away before coming back to South Korea. I read in your website that your friends and colleagues will keep your site. I am happy to see that your friends and colleagues continue the mission of making the earth better by energy recycling. I believe that the priceless effort will make a wonderful and great result some day. But all your friends (including myself) and colleagues will miss you. You were so good a friend and a man who had a great ideal for the earth. I pray for you to sleep in everlasting peace in heaven. I love you, my dear friend Al.
Kyung-ihl

Al was a good friend to me as well as to many other people. We used to go to lunch frequently at the Chinese Buffet, and afterwords, I would help him with various computer problems, or we would just discuss life and anything and everything. He was a sweet, kind, gentle man, and the world is a lesser place at the loss of him. Also, extremely intelligent man, and I will miss our many long conversations. I counted him as one of my best friends. Oddly, just few days ago I had a premonition about Al passing. Although, since I am often prone to negative thinking, I didn't give much thought to it. Just as the world is a lesser place because of his passing, I too am a lesser person from the loss of his presents in my life. He will truly be missed. I also want to thank Woody and his family for the kindness they haveshown Al.
With the deepest sense of loss.
Steve

There are few people in this world, who have earned the label, "the best." Al Rutan was one of them. He was one of a small handful of researchers, and teachers, who inspired me to get so involved in alternative energy, and self reliance, to become professional, and take up the cause myself. I know that I am only one of thousands, who have been so inspired by this man. If you have only recently discovered him, through his writing in the first issue of ESSN, you may not know what a great man he was, and how fortunate we were to be associated with him. I was looking forward to the opportunity to get to know him personally, through our shared venture. I guess you could say that he was the George Washington of small scale methane production. In his field, he was truly 'The Man.' At least for me, it was, and always will be, literally impossible to think of methane production, without thinking of Al Rutan, The Methane Man.
-Laren Corie-
Integral Solar Building Design Since 1975

I am really sorry to hear this news! I traveled around the country this fall talking with peopel about biofuels, and in this traveling, I heard quite a few different people mention Al as a pioneer in his field. So I was really excited to hear that he was contributing to the ESSN e-zine. He really rounded out the do-it-yourself biofuels picture with the important work he was doing.
Girl Mark

I was saddenend by this news, and at the same time heartened to remember Al's ever-friendly willingness to share information, and the way he was supportive of even the smaller projects and more innovative schemes. Makes me think about whether I'm living a worthy life.
Alex DePillis

By His Friends

Farewells From The Renewable Energy Family

I knew and worked with Al for many years. I believe we meet in about 1968 I was blessed to work near him for many of the following years. He was a pillar of integrity a pioneer, a leader and a teacher. He was the most kind, friend of the world, and lead and inspired many people in his concern for the environment, energy and human kind. In his gentle quiet approach he could be heard above the screaming of zealots. He always had an ear to hear, encouragement in the downturns, and a pat on the back to say we will overcome. He influenced many and remains in there memories, I know he remains in mine. I am relieved to know he was with friends, and in peace when he journeyed on. God and Gia blessed him, and may God and Gia bless all those who knew and loved him.
Darryl Thayer

Sorry to hear this. I just read his article in ESSN the day before I heard. Recumbent cycling also lost one of its great pioneers in Gardner Martin a few months ago. He was also a close friend of mine so I can sympathize with you.
Bryan J. Ball, Managing Editor
BentRiderOnline

Goodbye Al. We will miss you. You brought humanity a great gift of knowledge, experience, and love. Your passing has left a great hole in the fabric of our existence, one we will attempt to fill, with great difficulty. Your efforts in bringing clean, renewable power and food to the masses will not go unrecognized, unrewarded, or forgotten. We will miss you, but we will carry on. We will carry on your message, and your work, and make sure that your efforts were not in vain. Sleep well my friend, you did good.
Steve Spence, Director
Green-Trust

I am so sorry to hear of the loss of such a kind soul. Though I never knew him, I do believe that I would have been proud to shake hands with him, and become a friend. Life can be so unfair, as it seems that only the most decent people are subject to the greatest losses. Perhaps we can all name a year that was our worst. 2004 was mine, as four of my beloved companions left this earth, to venture towards their final destiny. My feelings are with you, Steve. Be well, and know that your friend looks upon you from his new home in heaven.
Best wishes,
Steve, creator of the Amptramp.

Al Rutan
The Methane Man
Rest In Peace

Electricity 101
The Basics

by Larry D. Barr and Steve Spence

There have been a lot of posts recently on various renewable energy groups from folks who are asking for help understanding electrical basics. For those who are endeavoring to plan and install their own RE system, be it wind, PV or hydro, a solid grounding (no pun intended) in the basics of electricity is essential. You don't need to be an electrical engineer, but there are some things that you absolutely must know. In this article, and the ones to follow, we'll teach you those things.

What is electricity? Very simply, it's the flow of electrons (those little things that orbit the nucleus of an atom) from one place to another. Preferably under control. Lightning is electricity. But not in a form mere humans can control.

Conventional electrical theory says that electricity flows from "positive" to "negative." That's not strictly true. Electrons carry a negative charge and actually travel from an area or object with a surplus or excess of them (a negatively charged area), to an area or object that has fewer (a positively charged area). So, the actual flow is from negative to positive – but we're going to stick with conventional 'positive to negative' theory for this series of articles. Ben Franklin started it, and that's good enough for me..

Let's talk for a few minutes about the minimal amount of math we'll need to understand in order to plan and install our renewable energy system. It's quite painless, really.

There are four essential parameters that we use to measure what's happening in an electrical circuit or path. They are: voltage, which is measured in volts, and represents the pressure or intensity of the flow of electrons; current, measured in amperes or amps, is the amount or volume of the flow: power, measured in watts, is the product of the voltage and the current and is the total amount of energy flowing through the circuit at a given time and; resistance, which is measured in ohms and is exactly what its name implies, a restriction or resistance to the flow of electrons in the circuit.

We'll also discuss a couple other terms which you'll run across in your pursuit of energy independence, but once we cover the four essentials above, you'll be able to see just how they fit in and why we need them. So, let's get to the basics.

The behavior of voltage, current, resistance and power are described by, and calculated with, a series of formulae known as Ohm's Law. It's named in recognition of Georg Simon Ohm, who discovered the relationship between them.

In the formulae of Ohm's Law, voltage is signified by "E", current by "I", resistance by "R" and power by "P". Here's how they work with each other. We'll use "*" to denote multiplication, like the computer folks do and "/" to show division.

E = I * R, meaning that voltage can be calculated by multiplying the current flowing in a circuit by the resistance that's in the circuit path. As an example, if there are 2 amperes of current measured in a circuit with a 6 ohm resistor, the circuit voltage is 12 volts.

We all learned how to transpose terms in first year algebra, so let's have a short flashback to high school and derive the rest of the equations that we'll need.to completely understand Ohm's Law.

Transposition of terms in an equation isn't difficult, so don't shy away from it. In this case, it merely involves dividing both sides of the equation by the same term. Didn't think you were going to get an algebra refresher in this article, did you? Let's get to it.

First, we'll transpose the terms so that we can solve the equation for current. That's "I", remember? Here's how we do it. Starting with our original formula:

E = I * R

Dividing both sides by "R" yields E / R = (I * R) / R which equates to:

E / R = I and reversing the terms to fit the standard format leaves us with:

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Electricity 101, continued . . .

I = E / R

Let's see if it works in our example circuit. We've already said that we have 12 volts flowing in a circuit which contains 6 ohms of resistance. So, it checks out. Twelve volts divided by six ohms equals two amperes of current flowing in the circuit. That didn't hurt, so let's solve for resistance. Again, starting with our original formula:

E = I * R

Dividing both sides by "I" yields E / I = (I * R) / I equating to:

E / I = R and, again, reversing the terms to put the unknown to the left, we have:

R = E / I

Testing once again, in our 12 volt circuit that's flowing 2 amperes, we divide 12 by 2 and, sure enough, we verify that our resistor is, in fact, six ohms.

That's nice and neat and mathematically correct, but what can we really use it for? Well, suppose that we'd like to use an LED to indicate when a 12 volt circuit is ON. That's great, except that LEDs aren't designed to operate on 12 volts and, if you apply 12 volts to them, they will suddenly cease to function. Permanently.

There are a few (expensive) exceptions, but the average LED is designed to operate at 1.2 volts DC at a maximum current of 20 milliamperes. That's 20/1000 of an amp. Now, here is a situation where the immutable law of Georg Ohm comes in real handy. Let's run the numbers and see just what value resistor we need to keep the LED from going into failure mode when we flip the switch.

We're looking to find what value of resistor we need so we'll solve for resistance, using R = E / I. So, what values do we plug into the equation? The LED wants to see 1.2 volts. We have a 12 volt circuit. That means that we need to lose (the technical term is drop) 10.8 volts. The optimum current for the LED is 20 milliamperes, 20 one-thousandths of an amp. That's written as 0.020 amps. So, the equation sets up like this:

R = 10.8 / 0.020 Yes, you can use your calculator if you'd like. I used mine and came up with R = 540 ohms. Don't drive the guys at Radio Shack nuts looking for a 540 ohm resistor, just take the closest standard value of 560 ohms. A 1/8 watt rating will be fine. Just between you and me, I generally use a 470 ohm resistor for my LEDs on 12 volts. But 560 ohms is really the proper value. You can run the numbers if you'd like, but using a 470 ohm resistor drives the LED with 22.9 mils of current. Not enough to hurt it. And it's usually easier to find 470 ohm resistors.

So where do watts fit into this picture? They are a measure of the power that you're drawing from your battery bank (or that's being consumed by a load) at any given time. Let's run a couple of calcs just to see how it works. Suppose you have a lamp that's drawing 5 amps (amperes) of current on your 12 volt circuit. It's consuming 60 watts of power. How did we arrive at that figure?

P (watts) = E (volts) * I (amps)

No problem, right?

Now, let's add a term that you're familiar with from paying your grid electric bill each month. That term is watt-hour. Along with kilowatt-hour, it's the most common term describing power used over time. It simply describes one watt consumed for a period of one hour. It could just as easily be watt-second or watt-minute. Which would, of course, be a watt consumed for either a second or a minute. Just for the record, one watt-hour is the same as 60 watt-minutes. See how it works?

A couple of examples will help clarify the concept. Let's take that 60 watt lamp and run it for one hour. We've just consumed 60 watt-hours of power. If we run it for 10 hours, we've consumed 600 watt-hours of power. And, if we leave it burning for 100 hours, we've used 6000 watt-hours of electricity. That last can also be described as 6 kilowatt-hours, since "kilo' is a Greek prefix meaning one thousand. And kilowatt-hours is the unit in which your grid bill is figured each month.

Amperes is another parameter which can be measured over time. We use ampere-hours to denote the ca-

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Electricity 101, continued . . .

pacity of a battery or battery bank. Remember that it's a measure of current delivered over time. For example, one of my EverStart P/N 27DC-6 12 volt batteries, which is rated at 115 amp-hours, will theoretically deliver 115 amps continuously for one hour. Or, 57.5 amps for 2 hours, or 1 amp for 115 hours. Or, any other combination of those numbers. I say theoretically, because things in real life don't happen exactly that way, but learn the math now and we'll get to the caveats later. At the risk of "over-simplication" (Pat Paulsen, 1968), figure the true capacity of a battery bank at 50% of the nameplate rating. That's because you shouldn't discharge your battery bank below half of its capacity. It will shorten the life of the batteries. For a complete explanation of what happens inside a lead-acid battery and how to maximize their life, point your internet browser to the "Downloads" page at http://www.rebelwolf.com and download the "Battery Service Manual."

A couple of the terms that confuse people who are new to things electrical are "series" and "parallel." Just what is the difference between them and how does it affect us? We most often find these terms applied to battery banks. And, the answer is really very simple.

A series connection means that the negative terminal of one battery is connected to the positive terminal of the other battery and the connection to the outside world is taken from the free positive of the first one and the unconnected negative of the other.

A parallel connection results from tying the two positives together, the two negatives together and deriving power from the positive and negative of either one.

When two batteries of like voltage are connected in series, the voltages add and the ampacity (amp-hour capacity) remains the same as for one. An example: if I connect two 6 volt Trojan T-105 batteries in series, the result will be a battery bank of 12 volts with the same ampacity as one 225 amp-hour battery.

In a parallel connection, the voltage remains the same as for a single battery, but the ampacity is the sum of the connected batteries. Given the same pair of Trojan T-105s, but in parallel this time, the resultant battery bank will yield 450 amp-hours at six volts. Or, four of the EverStart 12 volt, 115 amp-hour batteries in parallel will yield a 12 volt bank with an ampacity of 460 amp-hours.

Another commonly used connection scheme is series-parallel, in which series connected strings of batteries are wired in parallel to yield a bank of both higher voltage and higher ampacity than that derived from a single battery. Again, an example. Let's consider a bank of 16 Trojan T-105 6 volt, 225 amp-hour batteries, consisting of four series strings of 4 batteries, all connected in parallel. This would yield a battery bank with an output of 24 volts and an ampacity of 900 amp-hours. Each series string would have a voltage of 24 (4 * 6) volts and an ampacity of 225 amp-hours. Connecting the four strings in parallel would yield a total voltage of 24 volts, while the ampacities would be additive for a final value of 900 (4 * 225) amp-hours.

That's probably enough technical talk for this month and this article. We'll be back next month with more "Basics of Electricity."

Instant Sunspaces

by Laren Corie

Last month I introduced you to some basic theoretical stuff, but that can get old quickly, if it is all you get, and I would hate to chase you all off this early in the game. So, I want to dedicate this month's article, and many in the future, to how you can take that theory, and turn it into a reality in your life, and the lives of those around you. If you soaked in the information from last month, you probably got the message that sunspaces make pretty good Solar heaters, for most any climate. They also make very enjoyable additions to most any house. Just today, in the midst of the gloomy days of a Great lakes winter, while it was only about 10°F outside, I basked in the heat of the intense January sun, in a sunspace that cost me less than what most of us carry around as pocket change.

Can that be possible? Most definitely. You can build a simple sunspace that will pay for itself, maybe even multiple times, before the end of this year's heating season. It is even possible for it to pay for itself, in the very first month. Not only is there that benefit, and the one of being able to lounge around on your beach chair, wearing shades on a freezing winter day, but you can also use it for a sort of real world 'test drive' of a sunspace design you have been wondering about. The savings on your heating bill, will 'pay' you to build a temporary one, to experience how well it works.

Will it get too much shade to put out heat in December? Will it over-heat badly in the summer? Will it work better with clear or solid insulated side walls? Is the roof glazing too shallow? Will the planned venting keep it cool in the summer? Does the warm air circulate properly? How will the shape look on my house? Is it big enough to fit the furniture I want in it? How much heat will this thing really put out? Will it still heat up if I build it off the east or west wall of the house? Or any other questions about your dream sunspace that are tough to answer..

Now, you can 'really' find out, while saving more money than you spend, with less work than it takes to fool with a program that bases most of its conclusions on assumptions and your guesses. This is the real deal, right there in the real world, on your real house, collecting real Solar heat. And, you can build it cheap and fast. Then you can walk into, and experience the real thing. Or maybe you just need some free Solar heating, on your rented house, apartment balcony, or the parked bus you live in. So let's get started....

What do you need?

- A location where you want a sunspace.
- An idea (basic design) of what you want.
- Some wood for the light weight frame.
- A way to connect the framing together.
- A roll of clear polyethylene.
- A way to attach the poly film to the frame..

Here is what I built in a few casual hours with $22 worth of new materials.

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Instant Sunspaces, continued . . .

Had it not been for the careful fitting, to avoid making holes in the house, or using any caulk, it probably would have taken two hours, tops. Though my little sunspace only required that I build one wall, the same appraoch can produce one with three walls and a roof. If you want it to act like one with an opaque, insulated roof, you can use black polyethylene or just paint the roof. It will heat up enough in direct sunshine to fairly well balance its heat loss, and simulate a well insulated roof, on sunny winter days.. For summer you would want to add a second black roof, to shade the main one, with about a 6" or more gap between, for air circulation. You could also insulate the ceiling, if you wish. It all depends on what you want to find out. This is not a permanent structure.

I created about 100ft² of collector. The polyethylene that I used is 6 mil, though 4 mil would have been more clear and glass like, and in most cases, plenty strong enough. The wood is 2x2, ripped down from 2x4s. I used deck screws for connecting the frame, and Liquid Nails adhesive for attaching the polyethylene to the frame. All of the materials, except for the adhesive, and possibly part of the polyethylene, can be reused for other projects, so the cost is really even lower than the $22 it cost me. In some areas, the polyethylene will degrade from UV exposure, and only last one season. There is special greenhouse polyethylene, which is UV treated, if you want something that will last a little longer. It costs more, so you will have to decide if it is worth your investment. You may have enough lumber laying around already, and the polyethylene like I used is only about 3¢/ft² The Liquid nails was $2-3 for the two tubes, but staples would work too. This is Solar, with almost no initial cost. As far as building skills, if you can draw it with straight lines, you can build it this way. There are even ways to make curves (with lattice strips), if you really need to.

Here is my frame, fitted to the building, before I took it down to stretch the poly over it. It is about 12ft wide, and between 8ft and 9ft high. Though there were already what would be considered very big windows on that wall. They were about 50% shaded most of the winter, so the sunspace has increased the effective Solar gain by about eight times.

I was concerned, on this house, to not make work for myself when I take this sunspace down at the end of the heating season. There is no caulking or any other attachment, except for the pressure of the fit and two tiny screw holes, up through the vinyl soffit to hold the whole thing in place. It has gone through some pretty tough winds, with no sign of movement. Your detailing will be up to you, and your situation.

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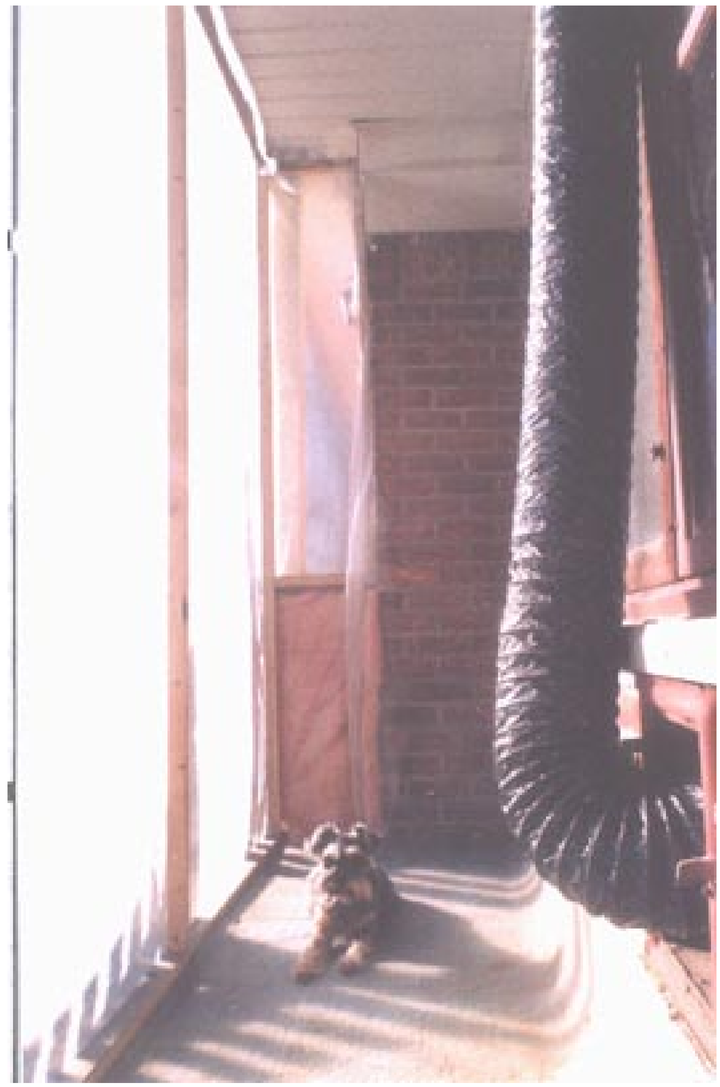
Instant Sunspaces, continued . . .

As you will recall from last months article, I often use terms like “Low (thermal) Mass Sunspace. What that means is that the interior has as little heavy materials as possible. I also consider that to be a very good thing, and neccesary for high performance, in most cold climates. This is the opposite of what you will read in almost every book on passive Solar design, so let me explain.

A Sunspace is basically a big walk-in Solar panel, with the objective of heating the house. For it to heat the house, we need to minimize the heat loss through the glazing (glass, polyethylene, etc), and move the heat into the house. One of the best ways we can do that is to reduce the time that the sunspace is warm, to only when the sun is shining. We do not want to store the heat in the sunspace, because that would force us to use it up, heating the sunspace all night. We only want heat storage in places that we **do** want to heat later, like inside the house.. A sunspace has almost no insulation value, so we can kiss all the heat left out there goodbye. Thermal mass in a sunspace is like leaving your car running in the garage all night, every night. It is so wasteful that there is very often nothing left over, much less the very high percentage of house heating, that “Low Thermal Mass Sunspaces” are capable of providing. This is particularly true of single glazed sunspaces, which usually have more net heat gain on sunny days than double glazed ones, but have over twice the heat loss, twenty four hours a day. Store your heat inside the house, where it is insulated. Then, if you ever want the sunspace heated at night, open the door to the house, and even turn on a fan. Let the house give it back only as much as is needed.

On the existing wall of my little demo sunspace, there is brick on three sides and an uninsulated concrete slab floor. That is a lot of thermal mass, exactly what all those books tell you that you would want. However, it keeps the heat of the daily sun in the sunspace, instead of allowing it to get to the house. Also, that mass is icy cold in the morning, and it may take the whole day of sunshine just to warm it up to room temperature. A sunspace at room temperature can not give any heat to the house. It has to be warmer than the house to do that. So it was important that I prevent the sunlight from shining on the brick and concrete. This is very important, if you are in any of the tough Solar climates, that I mentioned in last month’s article. On this little temporary sunspace, I used scrap carpeting to cover the south facing brick, and about 75% of the floor. I left the rest of the floor, and the brick end walls exposed. This only partially corrected the very bad excessive mass problem in this sunspace, but it still works very effectively, and gives a great idea of how much better a proper low-mass design would function.



The fan powered duct, through the convenient milk chute, is just an option that I rigged so I can lock up the house and still get the warm air to the inside. When I am around I simply open the door, and the air flows quite well naturally. The pup is not the only one who takes great pleasure in lounging around in the sunspace on a brisk January day.

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Instant Sunspaces, continued . . .

Every house is different, and you all will have your own unique needs and wants. I hope this demonstrates an extremely simple and low cost way to experience the wonder of Solar heating, and save a few bucks at the same time. You can also use this same simple “2x frame and poly film” approach mounted onto a wall, without the big ‘space’ part of the sunspace. When vented to the house that would be a very simple Solar air panel. Just remember that the closer the wall is to the glazing, the darker it needs to be, to prevent the light from being reflected back outside.

I hope this has your imagination going, thinking up all the new ideas you can bring into the real world, instead of just dreaming about them, or trying to model how they might work. There are few joys, better than the warmth of the winter sun, once you have learned to harness it. Sunspaces, not only heat well. They feel great, too.

May your winter days be bright,
-Laren Corie-

Meet The Writer

I designed my first Solar house nearly thirty years ago. After that, I helped a builder friend with a few designs, while spending as much time actually building as I could. Eventually, I had enough projects completed to land jobs teaching design, building, and energy courses. Soon I had an fulltime design practice going, and in time, completed about a hundred and fifty unique custom designed Solar homes that pushed the envelope of Solar and alternative housing design, in one way or many. I have always strived for continual improvement, with every design. It has also been my philosophy to share what I have learned with others, and I have generally found much personal satisfaction, in doing so. Though I took a few years off, to live a much simpler life up in the north woods, I have found that the internet has rekindled my interest in once again spreading the word, that there are better ways for us to build our homes.
Laren Corie

Off-Grid Journal

by Steve Spence, Director
www.Green-Trust.org

When we left the NJ/NY Metro area, we initially stayed at a friends motel, while we looked for a home. Between that, and a pop-up camper with some extended camping, we were able to take some time finding appropriate housing. We found a mobile home to rent for a year while we continued to look for a permanent spot. Some friends who had bought 5 acres of my family's original homestead had retired to Florida, and wanted to sell out. The only "issue" was that the property in the woods, and too far from power lines to be cost-effectively connected to the grid, and was in rough shape due to extended vacancy. Perfect! We moved in June 1st, 2004, and started renovating.

Resuscitating the original pv/wind/battery power system was a priority, reconnecting propane lines and appliances, and cleaning the wood fired heating system. Walls and cupboards were cleaned and painted, floors carpeted, and plumbing fixed. Soon we had electric, water, and heat, in a clean, serviceable, but simple home. The original gasoline generator was toast, so we borrowed another while we looked for a permanent diesel power system, to be fueled with clean burning, renewable vegetable oil. All was rosy, comfortable, and idyllic, right?

There are times when my enthusiasm for living off-grid has masked some of the trials of taking on the responsibility of providing for my family, what is usually left to "civilization". The "grid" of services and products that insulate us from what our forefathers had to deal with, the experiences that made them what they were. Those experiences built character, but it was not an easy life, and many did not survive. When one takes on those responsibilities locally, they remove the safety net of the cushy life, and decide that character is more important than comfort. This is not an easy process, and many quit, and go back to "the good life" of grid supplied power, heat, and food. We believe that providing for ourselves makes us healthier, not only physically, but mentally as well. We are the new pioneers. The trials can be significant, and expensive. Recently our venerable old cast iron woodstove split apart, and had to be replaced. We now have one that is twice as efficient, and much safer. The starter on our generator went out, and we had limited power for 3 days. Candle light dinner is romantic, but laundromats are expensive, and far away. Yesterday I traveled 400 miles for 1000 gallons of used veggie oil for the generator, but now I have enough fuel to power us for 3 months. It's time to plan the garden, so we have food for the coming year, but it will be better food than the grocery store used to supply. Every "issue" that is dealt to us, is not a "setback" to be overcome, but a learning experience in which we gain knowledge, and learn to be better citizens of humanity. Our journey continues .....

Energy Conservation

The First Step to Energy Self Sufficiency

by Larry D. Barr, Editor

I know I've mentioned it before, and you should know I'll undoubtedly mention it again. But the simple fact is that unless you have cubic dollars to waste on more generating devices than you really need, you'll never acheive energy self sufficiency without energy conservation.

For those of us who are seeking energy self sufficiency to save funds as well as Nature's resources, conservation is essential. It allows us to meet our goal without spending unnecessary money on PV, wind or hydro devices, and gives us the pride and benefits of grid independence for a much lower initial investment.

And for those, like me, who are still striving for energy self sufficiency and the off-grid life (again), conservation is an invaluable way to keep money that used to go to the utility company each month. Money that I'll use to buy my land and build my off-grid home. And there will be an extra bit of satisfaction knowing that part of the funds for my off-grid homestead was indirectly financed by the utility company. What a thought!

Conservation isn't difficult. It can start with something as simple as making sure that lights are shut off in unused rooms. Use compact fluorescent lamps, put a timer on the electric water heater and shut it down while you're away from home. Take a look around your home. You'll think of more ways to conserve our resources. It's worth it -- in many ways. ldb

Al Eggen's Trickle Collector Project

A Work In Progress

Al Eggen, a mechanical engineer, sent us these reports of his development efforts on a solar trickle collector project. Part 3 will appear in the March issue. ldb

INITAL TRICKLE COLLECTOR EXPERIMENTS
Preliminary Report
1/21/03

The Apparatus

The absorber is a short length of 29 gage (0.0141") galvanized steel roofing painted black. The corrugations are 3" oc, with 1" flat ridge and valley, and 0.5" depth. It has 2 coats of Derusto Hi-Heat Finish, in H-63 black, on a Galvinoleum undercoat (all old paints, brush applied). I'm assuming an absorptivity of 0.90 and an emissivity of 0.95, but this really is just a guess. The absorber lays on 2" xps (Dow blue board), which is supported on a hollow core door. A collection trough, bent from aluminum flashing, has a leg that slides underneath the absorber. The collector is framed in with wood sides and top, which extend approximately 1" above the absorber ridge. The collector is masked to expose only 30.5" by 59" (12.5 sf) of absorber. For this first test set, the collector was unglazed. Because of morning shading, the collector faces west of south (aligned with the sun at roughly 2 pm). It is set at a 5/12-pitch (22.5^o).

A CPVC manifold (0.68" id), drilled with 10 - 1/16" diameter holes, to match the valley centers, goes across the top of the collector. The manifold inlet, and collection trough outlet, are plumbed with modified plastic tees to allow for water temperature measurement. However, these measurements turned out to be too inaccurate to be useful so they were eliminated. The opposite end of the manifold has a connection to clear vinyl tubing, which serves as a manometer. A Rule, 500 gph, submersible, 12 volt bilge pump, in a 5 gallon bucket (calibrated for volume), feeds water to the manifold via clear vinyl tubing. A clamp on the tubing controls flow. The outlet trough feeds back into the bucket to make a closed circuit. A battery charger provides power for the pump.

Insolation is measured with a dp Solar Meter, model 776, placed right on the center of the collector. Water temperature is measured with a mercury thermometer (2^o graduations). A Heliotrope general thermistor probe, with copper end, is screw attached to the underside of the absorber at the center of the center ridge. A second probe is similarly attached at the center of the adjacent valley. They are read by a Heliotrope General ET-0/350 electronic thermometer with analog readout. Ambient temperature and humidity are read by an Extech electronic thermometer/hydrometer.

The Experiment

Flow calibration of the manifold determined that for the 10-hole manifold:

$$gpm = 0.166(H)^{1/2}$$

where H is the head on the manifold holes in "H_2O. The design flow was 0.5 gpm, which requires a head of 9.1". This was based on a per hole flow of 3 gph. This would result in a flow of 12 gph/ft of collector width for 3" oc corrugations, or 1 gph/sf for a 12' collector. (Note that the flow characteristics – which determine internal collector performance – are defined primarily by the flow per corrugation, not the flow per unit collector area.)

After some preliminary tests and dry performance runs, a wet performance run was made on 3/14/03. The collector was covered with a plastic tarp until the test started. Snow was packed on top of the tarp to keep the absorber cool. At the start of the test, the absorber temperature was 36F. Five gallons of water were at 37F when the test started. Unfortunately, the flow control clamp was too loose at start and about ½ gallon of water was blown out the manometer before flow was stabilized.

The test basically consisted of measuring temperatures and insolation vs time while keeping the flow constant at 0.5 gpm. The stored water temperature, Ts, peaked at about 75F, then slowly dropping to 74F by the end of the test. The ambient temperature, To, was about 28F. The end point also came at about the time tree branch shadowing was beginning. The test then continued by tracking the cool down of the water bucket with no solar input.

Results

The storage water bucket heat loss coefficient, obtained from the cool down portion of the test, was 7.5 Btuh/F. The storage water heat gain can be calculated from the rate of temperature (Ts) rise. However, this calculation is very sensi-

Continued on Next Page

Trickle Collector, continued . . .

tive to the temperature-time curve. Although the measured data makes a reasonably smooth curve, there is scatter. A breeze, some very thin clouds, reading errors, and the lack of precision in temperature measurement, all will have their effect. To get more meaningful data, a smoothed temperature profile was developed. (Not only must Ts vs t be smooth, but also its derivative, dTs/dt.) The heat gain by the stored water then could be calculated. The solar heat collected, q, is equal to this heat gain, plus the heat loss from the storage water bucket, minus the heat imput from the pump. The temperature of the water delivered by the collector, Tw, is higher than Ts by the amount necessary to deliver the solar gain to the water in the bucket. Figure 1 shows the measured and soothed values of Ts, and the calculated value of Tw, as functions of time. Figure 2 shows the efficiency, E, both from measured data, and smoothed data, plotted vs (Tw-To)/I.

The two absorber temperature probes read quite close together when no water is running, so that temperature differences between them probably are reasonably reliable. However, the temperature readings themselves are somewhat uncertain. Therefore, until I can calibrate the probes, only the differences will be presented. Figure 3 shows the temperature difference between ridge and valley, as a function of q. This is a measure of the fin effect, and certainly is significant.

There are two different zero efficiency cases: dry, and with trickle flow. In the second case, evaporation from the trickle water cools the absorber below what it would be dry. Absorber temperatures are quite sensitive to a breeze so they jump around quite a bit. As a result, the values of (Ta-To)/I, dry, E = 0, range between 0.32 and 0.39 with an average of 0.35. If we assume an emissivity, e = 0.95, we can calculate the effective radiation coefficient, hr, from

$$hr = 0.1713e\{[(Ta+460)/100]^4 - 0.0285[(To+460)/100]^6\}/(Ta - To)$$

With that, and assuming an absorbtivity, a = 0.9, the convection coefficient, hc = 1.1 Btuh/sf-F, based on nominal collector area. Correcting for the added area of the corrugated absorber (x 1.14), the convection coefficient, based on actual area, was 1.0 Btuh/sf-F. Note that the conditions were a light breeze in a sheltered location.

The heat lost from evaporation, qe, can be approximated by:

$$qe = 100FaAw/A(V - v)$$

where Fa is an activity factor, Aw/A is the fraction of absorber covered with water, V and v are the saturation vapor pressures in “Hg at Tw and To. From figure 2, I estimated the E = 0 value of (Tw – To)/I = 0.245. Then, together with the convection coefficient from the dry case, the evaporation factor can be calculated. The result is FaAw/A = 0.68. This factor could be expected to be a function of flow/hole, collector slope, and absorber surface configuration.

At this point I would remind the reader that these last calculations are based on a rather long series of assumptions and approximations, and should be used with this cravat in mind.

Once I’m surer of my absorber temperature measurements, I will attempt to assess the magnitude of the heat transfer coefficient between absorber and water – or at least determine if it will have a significant effect on collector performance. Testing will continue with the collector glazed (Kalwal).

TRICKLE COLLECTORS EXPERIMENTS
Progress Report 2
4/7/03

Corrections and Additions to Report 1

Corrections

The absorber ridge and valley temperature probes were roughly calibrated since the first report was written. However, these probes should not be considered as especially precise or accurate, especially at higher temperatures. Also, because the probes respond quite rapidly to variables such as the breeze or the flow path of the trickle water, a great deal of scatter can be expected. The corrected temperature vs. time data, including ridge and valley temperatures, are shown on revised figure1.

After correcting the absorber temperatures, and revising the analysis of process occurring on the unglazed collector, new values for the convection and evaporation rate coefficients, were calculated. The changes were small. The new results are:

hc = 1.0 Btuh/sf-F, based on projected area
hc = 0.9 Btuh/sf-F, based on actual surface area
FaAw/A = 0.71

Note again that the conditions were a light breeze in a sheltered area. The analysis follows.

Continued on Next Page

Trickle Collector, continued . . .

Analysis – Unglazed Collector

The analysis of a trickle flow collector requires a heat balance on three separate components: the absorber itself, the trickle water, and the glazing. The analysis of the unglazed version is greatly simplified by the elimination of the glazing component. Since water is essentially transparent to solar wavelengths, all of the solar energy strikes the absorber. Since the water is essentially black to long wave lengths, reradiation comes from the water surface rather than the absorber beneath the water. The absorber balance:

solar energy absorbed = aI
heat loss by radiation = qra = hra (1 – Aw/A)(Tam – To)
heat lost by convection = qca = hc(1 – Aw/A)(Tam – To)
heat transferred to water = qw = hAw/A(Tv – Twm)

where

Tam = (Tr + Tv)/2
Twm = (Tw + To)/2

and the balance is

aI = qra + qca + qw

For the water the heat flows are:

heat transferred from the absorber = qw
lost by radiation = qr = hrAw/A(Twm – To)
lost by convection = qc = hcAw/A(Twm – To)
lost by evaporation = 100(V – v)FaAw/A

V and v are the vapor pressures ("Hg) at the water temperature and the dew point of the ambient surroundings. The net gain by the water then is:

q = qw – qr – qc – qe

The radiation coefficients really are just convenient fictions. Assuming radiation to the sky, the radiation heat fluxes are:

qra = 0.1713e(1 – Aw/A){[(Tam+460)/100]^4 – 0.0285[(To+460)/100]^6}
qr = 0.1713eAw/A{[(Twm+460)/100]^4 – 0.0285[(To+460)/100]^6}

Combining the absorber and water balances gives:

aI = qra + qca + qr + qc + qe +q

Since E = q/I, this can be rearranged to the familiar format as follows

E = a – {(qra + qca + qr + qc + qe)/(Tw – To)}{(Tw –To)/I}

Note that the qr's and qe's are functions of temperature - this is not a straight line relationship.

For a dry collector at stagnation (E = 0) the water related terms drop out. Since reasonable estimates can be made for the radiation terms, a collector outside convection coefficient can be calculated. With this coefficient, and trickle collector performance at E = 0, the evaporation constants can be estimated. The results for the 3/14/03 run data are given in the previous section. Note that though the estimates used in the calculation may be reasonable, there are a lot of them, so we don't want to bet the farm on the accuracy of the results.....

Results

Heat transfer between absorber and water is an important component of collector performance. Figure 1 revised shows valley temperature as only slightly higher than water temperature. However, the difference is larger than it seems because the water temperature actually varies from Ts at inlet to Tw at exit. Another factor to keep in mind, when examining the data, is the heat transfer to water includes not only the solar heat gain, but also the losses from the water itself.

The heat losses from the water surface can be estimated using the equations and constants from the previous sections. The results are shown as a function of time on revised figure 3, and a function of (Tw - To)/I on figure 4. As the water heats, efficiency goes down, and the heat collected, q, goes down with it. However, as the collector heats, all of the losses, and especially the evaporation loss, qe, go up. As a result, the total heat transferred to the water does not go down very rapidly. This can be seen in the temperature/time profiles, where the spread between absorber temperature and water stays fairly constant for much of the run.

Figure 5 shows the relationship between qw and the driving temperature difference, Tv – Twm. The scatter is very high – which should be expected since the temperature differences are so small – so it does take a bit of imagination to see a correlation. A least squares fit also is shown. The resulting convection coefficient is 210 Btuh/sf-F. This seems on the low side of what would be expected.

Continued on Next Page

Trickle Collector, continued . . .

From the temperature profiles it is obvious that the fin effect is quite significant. The amount of heat that had to be transferred through the thickness of the absorber metal, qfin, can be calculated in two different ways. The heat transferred through the fin is equal to the total heat transferred to the water, less the solar radiation absorbed directly under the water, or

qfin = qw – aI(Aw/A)

However, it also has to equal the solar radiation to the dry portion of the absorber, less the radiation and convection losses from that portion, or

qfin = aI(1-Aw/A) – qra – qca

These values depend on temperatures that were measured - and on q values calculated using constants estimated or derived from the zero efficiency experiments. There is no reason to expect the two calculations to yield the same result – and they don't. Figure 6 plots the values of qfin against each other. The degree of agreement is a measure of the accuracy of the calculations and assumptions, and actually is quite good.

Figure 7 plots both versions of qfin versus (Tr – Tv). The fin configuration is simple enough so that you can calculate the temperature profile and heat flow at the root if you assume the net solar heat absorbed is even over the surface of the absorber. For the absorber geometry, this works out to be

qfin = (kt/0.101s^2)(Tr – Tv)

For the 25 gage steel absorber, t = 0.0141", k = 26 Btuh/ft-F, and 3" oc corrugations, the result is

qfin = 4.8(Tr – Tv)

This value also is shown on figure 7, and is much lower than the measured values. This means that the net heat absorption is not even. The heat transfer through the fin is restricted enough so the ridge temperature must rise well above the valley temperature. When it does this, the heat loss to ambient also rises and more of the gain comes from the section closer to the water, reducing the amount carried from the ridge area.

The Experiments

The only change between this set of experiments and the first set is the addition of a single layer of Kalwall glazing to the collector. Short lengths of black polyethylene were screwed to the center rib of the absorber to act as standoffs. (One limitation of Kalwall – as well as any plastic glazings that are flexible enough to ship on a roll – is that they will sag and touch the absorber unless supported at very close intervals.) The perimeter of the absorber frame was topped with foam tape; the Kalwall was laid on top, and held in place by wood battens screwed down through the Kalwall. The space between the top of the absorber corrugations and the glazing was about ¾". I don't think there were any significant air leaks.

An approximate value for Kalwall solar transmittance (It/I = 0.88) was obtained by reading insolation above and below a section of Kalwall. The readings vary quite a bit depending on how far the meter was below the Kalwll. The highest readings were with the meter against or very close to the glazing.

Dry (stagnation) tests were made as well as a full efficiency run (3/25/03). The instrumentation and experimental procedure were the same as used for the unglazed collector tests, and described in the first report. There were some small water leaks, during the 3/25 test, that appeared to be due to water jumping the end corrugation. Moving the distribution manifold in and out a little did cure these leaks. The water loss (5 gal storage to start, 4.6 gal at finish) seemed high for the observed leaks. The efficiency calculations assumed the water portion of the storage heat capacity varied linearly from 5 gal at start to 4.6 gal at finish.

Analysis

Glazing adds considerable complexity to the collector analysis. The introduction of the glazing temperature into the heat transfer relationships makes it impossible to develop direct solutions. As a result, any performance calculations require some rather tedious trial and error calculations.

Experimentally, glazing temperature is very difficult to measure. The presence of any contact probe will itself change the local glazing temperature. Optical instruments offer a possibility, at least for glazings that are non-transmissive in the IR band. Careful, glazing specific calibration still would be required. However, optical temperature instruments are not part of my collection, and so direct glazing temperature measurements will not be available for the present experiments.

The three heat balances can be written as follows. For the absorber:

Continued on Next Page

Trickle Collector, continued . . .

solar energy absorbed = aIt
heat loss by radiation = qra = hra (1 – Aw/A)(Tam – Tg)
heat lost by convection = qca = hci(1 – Aw/A)(Tam – Tg)
heat transferred to water = qw = hAw/A(Tv – Twm)

where It is the transmitted portion of the insolation, and the balance is

aIt = qra + qca + qw

For the water the heat flows are:

heat transferred from the absorber = qw
lost by radiation = qr = hrwAw/A(Twm – Tg)
lost by convection = qc = hciAw/A(Twm – Tg)
lost by evaporation = 100(V – v)FaAw/A

V and v are the vapor pressures ("Hg) at the water and glazing temperatures. The net gain by the water then is:

q = qw – qr – qc – qe

For the glazing:

solar energy absorbed = Ig
gain from inside = qra + qca + qr + qc + qe
loss to ambient, radiation = qro = hro(Tg – To)
loss, convection = qco = hc(Tg – To)

The glazing heat balance then can be written as:

Ig + qra + qca + qr + qc + qe = qro + qco

The radiation heat flows:

qra = 0.1713e(1 – Aw/A){[(Tam+460)/100]^4 – [(Tg+460)/100]^4}
qr = 0.1713eAw/A{[(Twm+460)/100]^4 – [(Tg+460)/100]^4}
qro = 0.1713e{[(Tg+460)/100]^4 – 0.0285[(To+460)/100]^6}

The usual approach to solution is to use the glazing balance to determine Tg. Once Tg is known the internal equations can be solved – assuming all the constants are known. In my opinion further algebra just complicates matters and numerical approaches are most effective and instructive when the individual relations are used.

Results

The temperature/time profiles for the 3/25/03 run are shown in figure 8. The data from the last end of the run has a rather high level of uncertainty. Very thin clouds came up, and insolation varied rather widely. This is at the stage where water temperature is near its peak and the efficiency calculation becomes sensitive to even very small temperature variations. The variability is demonstrated by the wild swings in absorber temperature, especially Tr. Beyond about 180 minutes, the smoothed Ts data departs from the measured data. Therefore, these last smoothed temperature data points were not used in any of the q or efficiency calculations.

The values of q calculated from the smoothed temperature data, and the insolation, are plotted as functions of time on figure 9. Note the large instability in I after about 160 minutes. Again, this illustrates why the end data from this run should not be taken too seriously.

The efficiency curve is shown on figure 10. Because of the above considerations I would assign a very high level of uncertainty to efficiency data beyond a dT/I of about 0.24. The data from smoothed temperatures looks like the efficiency is heading for zero at not much over dT/I = 0.25 – except that there are a fair number of points that suggest zero at something more like 0.3+. The measured data is widely scattered, but it does not suggest a nose-dive around 0.25.

Figure 10 also shows calculated efficiency points. The were obtained by using measured temperatures and insolation at various points (essentially picking dT/I values), together with the previously derived relations, to calculate the glazing temperature, the various heat flows, and the efficiency. The assumed values used in the calculation were:

Ig/I = 0.05
It/I = 0.88
a = 0.9
e = 0.95
hci = 0.34 Btuh/sf-F (from ASHRAE Fundamentals)
hc = 0.9
Aw/A = 0.5"/3" = 0.17
FaAw/A = 0.71

The fit is surprisingly good – probably too good to be true. It should be noted that this is not a full performance prediction

Continued on Next Page

Trickle Collector, continued . . .

since some measured internal temperatures were used. In order to do a complete prediction, the relation between q, water temperature rise, and flow rate, as well as absorber to water heat transfer, must be included. A task I will leave for another day – as it is, the data analysis spread sheet for the run extends to column BV and row 80 – and that doesn't include the prediction calculation.....

The stagnation runs produced values of (Ta – To)/I ranging from about 0.67 to 0.75 F/Btuh/sf. The lower values may have been due to a stronger breeze. The value predicted, using the above constants, was on the order of 0.75.

The absorber temperatures are plotted separately on figure 11 as (Tv – Twm) and (Tr – Tv) vs. time. These represent the driving force for absorber to water heat transfer, and fin heat transfer. The scatter is very high, which is not surprising. What did surprise was the high level of (Tv – Twm), which is almost as large as the fin delta T. For comparison, figure 12 is the equivalent plot for the unglazed collector. The scatter is less, the fin delta T is similar, but the water delta T is only about half as large. At this point I have no explanation for the difference, but more work with performance prediction calculations may provide some insight.

Some Conclusions

1. Unglazed trickle flow collectors potentially have application for some combined water heating/cooling applications, especially in warmer climates. Sunny day warm water delivery temperatures of 40F or so above ambient could be combined with night cooling. This temperature rise should be adequate for low temperature heating applications such as swimming pool heating, or for domestic hot water preheating. Alternatively, solar heating could be split to provide warm water for pool heating and dhw preheating, with a small glazed section to boost the temperature for dhw.

In a night cooling mode, the collector would operate as a kind of cooling tower with some night sky radiation thrown in. The equations developed in the analysis section, together with the constants obtained from the experiments, could be used to estimate performance.

2. The performance penalty due to fin heat transfer, as well as other issues that have been raised, make me recommend aluminum rather than steel for the trickle flow absorber. My next runs will use a 0.018" corrugated aluminum absorber. The conductivity/thickness product for this roofing is over 6 times better than that for the steel absorber used in these runs.

Terminology

a = absorptivity at solar wavelengths
A = absorber area, sf
Aw = area of absorber covered by water, sf
e = emissivity at temperature
E = efficiency = q/I
Fa = activity factor, used to account for the effects of water activity, wind speed, etc, on evaporation rate
h = absorber/water convection coefficient, Btuh/sf-F

hc = outside convection coefficient
hci = internal convection coefficient
hr = water surface radiation coefficient
hra = absorber radiation coefficient
hro = outside (glazing) radiation coefficient
I = insolation, Btuh/sf
Ig = insolation absorbed by glazing, Btuh/sf
It = insolation transmitted to absorber, Btuh/sf
k = thermal conductivity, Btuh/ft-F
q = net solar heat gain by water, Btuh/sf
qc = heat lost by water via convection
qca = by absorber via convection
qe = by water via evaporation
qfin = transmitted through absorber metal at the edge of the water
qr = lost by water via radiation
qra = by absorber via radiation
qw = heat transmitted from absorber to water
t = absorber thickness
Ta = absorber temperature, F
Tam = absorber mean temperature = (Tr-Tv)/2
Tg = glazing temperature
To = outside (ambient) temperature
Ts = water temperature in storage and at supply to collector
Tr = absorber center temperature at ridge
Tv = absorber center temperature at valley
Tw = water temperature leaving collector
Twm = mean collector water temperature = (Ts+Tw)/2
V = vapor pressure at water temperature, "Hg
v = vapor pressure at dew point of surroundings, "Hg

The Figures referred to in the article and Part 3 of this series will be in next month's issue. ldb

Organic Engines is a true Earth-Friendly company. Here is their trusty SUV hauling a load of bike boxes from a local shop. These will be used to ship shiny new SUV's off to their new owners. The author of this article is in the process of purchasing a pair of SUV pedicabs.

Human Powered Vehicles

"The Power of You"

by Bryan Ball

To many of us, transporting ourselves around by our own steam is not an entirely foreign concept. Commuting to work, running light errands and maybe even doing some grocery shopping are all activities that can be accomplished rather painlessly by bicycle. However, when the chores of daily life get a little bit more intense (moving furniture, lumber, large appliances, trade goods) most of us still fall right back into our petroleum-fueled bad habits.

That need not be the case. In fact, acquiring the right equipment and making human powered transportation a part of our daily lives doesn't even have to be expensive or difficult. For most people a sturdy mountain bike and a good trailer are all you'll ever really need.

Mountain bikes are preferable because most of them have fairly comfortable seating positions, powerful brakes, predictable handling and their frames are built to take a beating. Basic unsuspended models are preferable and make sure that the frame has attachment points for racks and fenders. They also have lower gears to make climbing hills with a large load a bit easier. Try to avoid department store brands but there's no need to spend a lot of money. Any used mechanically sound bike will do the job. I personally prefer a good rigid chromoly steel frame for this type of duty so buying used or lower end bikes are about my only option. Most new mountain bikes are made of aluminum and have at least front suspension.

For things like trips to the grocery store or the post office, a good rack and a set of panniers (the fancy name for bags that go on a bike rack) may be all that you need. Tubular chromoly racks are the sturdiest but may cost a bit more than the aluminum versions you're likely to find

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HPVs, continued . . .

at a department store. There are a lot of pannier choices out there. If you splurge a little bit and spend around $100 or so for a good set of quality waterproof panniers (Ortlieb, Arkel and Vaude make some of the best) they'll keep all of your belongings dry and secure and probably outlive you.

There are a myriad of trailer options out there to meet almost any load-carrying need. Probably the most popular amongst heavy commuters and tourers is the B.O.B. Yak single wheel trailer. It attaches to the bicycle via a modified rear quick release so it works well on recumbents and folders as well as normal diamond framed machines. If you prefer the stability of a two-wheel trailer but aren't looking for anything too huge, the Burley Nomad is a great option.

Building your own trailer is also not nearly as difficult as it may sound. Heavy gage steel electrical conduit makes a very good frame material and I've seen a few really nice quick-release hitches made from air hose fittings. If you're not going to be using it over any significant distances almost any wheels will do. Cheap 12" or 16" wheels intended for use on children's bikes work very well for most purposes.

If you need a trailer for really substantial loads but don't feel like building your own, I highly recommend the products of Bikes at Work. Their Spine trailers are pretty much the gold standard in this category. Many people also build their own trailers or improvise a light duty lawn tractor trailer if they want to haul larger loads.

For some people a trailer may just not be good enough. For hauling fairly heavy loads on a regular basis, a purpose-built cargo bike or trike may be a better choice. These machines are designed so that the load is not as likely to upset the handling. They also have robust frames so regular use isn't likely to damage them.

In the two wheel department the Eight Freight, designed by cycling luminary Mike Burrows, and the recumbent Bevo Bike are some of the best that I've ridden. The non-profit company, Human Powered Machines also makes excellent load haulers with both two and three wheels.

Here is a close-up of the imposing but oh-so useful Cycles Maximus trike. Cycles Maximus has also just released pedicab version of this machine.

A good load-hauling trike can be a major investment but for truly ridiculous loads, there really isn't a better choice. Load carrying trikes are available in both upright and recumbent versions. Some are intended for industrial use (low speed, short distance) while others are aimed at courier services or businesses that want to move their products over longer distances. By far the best upright load trike I've seen is the Cycles Maximus. It mates a front end that is similar to a BMX bike to a multi-gear drivetrain and a large cargo bed. Organic Engines of Talahassee, Florida makes an excellent recumbent load hauler called the SUV. This trike is front wheel drive and the driver leans the trike to steer it. Lightfoot Cycles also makes some excellent and more conventional utility trikes. They have several choices that are designed for industrial and personal use.

Hacking together your own load carrying trike can also be a fun project. It's amazing what you can do with a little know-how and a few donor bikes from the junkyard. Just make sure you really know what you're doing before you go barreling down the road at thirty mph with five sacks of concrete on a machine that you built yourself.

Continued on Next Page

Meet The Writer

It seems that I've pedaling around on something my entire life. I was into the BMX thing as a kid. That turned into a somewhat promising road racing career during my late teens. Then girls and sports cars took over for a little while. Eventually I came out of that slump and went on to race mountain bikes on a semi-professional level before a series of concussions and the birth of my first child woke me up. I was working at a bike shop when the recumbent bug struck and I've never looked back. However, it wasn't until a couple years later when I really got interested in anything I would call "human power". Up until that point, I was more interested in bikes as recreation and not as transportation. I commuted to work by bike but this was to try and fit in another hour or two of training time, not to save gasoline. As I got older my priorities definitely changed. I still take a lot of recreational and "training" rides but bicycles and homan powered vehicles have become much more than that. I see them as a way to really change people's daily lives. Getting out on a bike and actually "doing something" with it is a wonderful and powerful feeling. If you're an environmentally concious person who wants to limit their impact on this great planet as much as they possibly can, the feeling of satisfaction is increased even more. My main mission in life is to help spread that feeling to as many people as I can. I welcome the opportunity to work with the like-minded individuals here at ESSN in spreading the word, so to speak. Who knows ... Maybe we can even save the world a little bit in the process.

Bryan J.Ball, Editor/Publisher
http://www.bentrideronline.com

HPVs, continued . . .

While we're on the subject... Make sure that you take it easy when riding any bike with a significant load. Use the same logic that you would use when driving a car in the rain or snow. Everything is going to take just a bit longer than it usually does. The handling will be slower and the brakes won't work as well as they usually do. If you're using a rack or a trailer, try to put the weight as close to the centerline and as low as you can get it. A low center or gravity is paramount to good handling. And make sure that you NEVER exceed the weight limit on your vehicle or trailer.

Running errands with human power can be a very fun and exciting experience. It's quite satisfying to complete a job and know that you did it all by yourself without causing any harm to the environment. It's also good to just get outside and exercise. If the weather isn't too great, you at least have the pride of knowing that you conquered the elements.

If you're out of shape or inexperienced, don't overdo it. Start out with lighter loads and work your way up. You'll gain fitness and skill as you go. Cycling is sort of an "instant gratification" sport. It takes a lifetime to get the power needed to race at a competitive level but after a couple of months of steady riding most people will build all the muscle they need for occasional trips to the grocery.

Of course, human power is not going to work all of the time for everyone. But the next time a situation occurs where you could use your bike instead of your car, don't be so quick to reach for the keys. You may discover a wonderful new activity that you never knew you were missing.

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Circulation Info

Although there was a bit of confusion during the month of January, due to the problems we had with various hosting companies, we can safely say that our circulation for our Premiere Issue was very close to 9000. That's 6309 from the original host, 1390 as of 1847 31 January on our new and permanent host, and about 1300 split between the ill-fated intermittent host and Steve Spence's site. Not exactly perfect precision, but we'll have that from now on. Thanks to all of you. ldb