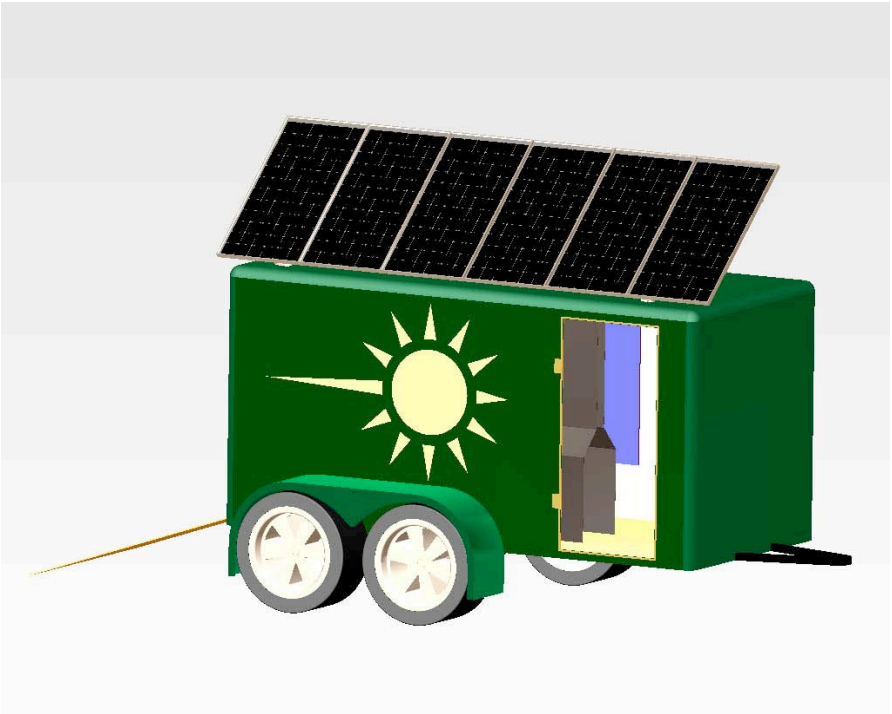
Mobile Renewable Energy Trailer Proposal

An Engineering 305 Group Project at Humboldt State University



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AstroPower

Campus Center for Appropriate Technology
Since 1978

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Special Thanks to:
Roger
Jennifer Crouse: AstroPower, Inc.
David Katz: Alternative Energy Engineering
Richard Engel: Schatz Energy Lab
Jim Zoellick: Schatz Energy Lab
Chris: Northern Winds Solar Lights
Stump: Northern Winds Solar Lights

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Background

Nine students from Humboldt State University (HSU) are developing a Mobile Renewable Energy Trailer as a group project for Engineering 305. We are designing and building the trailer through the guidance of professor Mike Manetas and the Co-directors at the Campus Center for Appropriate Technology (CCAT) on the HSU campus. CCAT is a program of the HSU Associated Students, and a registered non-profit organization. Funding for CCAT comes from the Humboldt State University Associated Students (AS), and from public and private donations to the non-profit.

The mission of CCAT is to demonstrate appropriate technology in a residential setting, to provide hands-on experiential learning opportunities to HSU and the surrounding community of Arcata, to collect and disseminate information about appropriate technology, to examine the ethical and social consequences of technology, and dispel the myth that living lightly on the earth is difficult or burdensome. This Mobile Photovoltaic Trailer project is very much aligned with CCAT's mission statement.

The PV trailer coordinators are working cooperatively with CCAT to produce a product that is both functional and educational. We are developing a trailer that can be used to power a PA system for public events such as the Renewable Energy Fair, our local farmers market in Arcata, and musical events in the main campus gathering area (the Quad). By powering such events with renewable energy we intend to generate dialog about appropriate technology, to raise consciousness regarding our interaction with the earth, and to proactively address our collective impact upon the environment within which we live. Ultimately this process of education is about introspection, insight, and empowerment for students.

Introduction

Imagine a mobile trailer capable of powering a musical act, political rally, or poetry reading on a sunny afternoon on the Humboldt State University campus. Visualize a mobile trailer that contains renewable energy devises, such as photovoltaic panels, providing all the electricity needed for a small event, yet completely derived from the sun. No wires plugged into the grid. No carbon dioxide being expelled into the atmosphere from a fossil fuel source. Now picture thousands of students and local community members enjoying the event (whatever it

happened to be on that particular day) and learning about this renewable power center on wheels. Interacting with it, talking about it with friends, experiencing it. How cool! The trailer those folks at the event would see would be aesthetically stunning, well designed, interesting to look at, full of educational diagrams about renewable energy, top notch interpretive displays describing the system, and a knowledgeable student representative whom they could ask questions. People would come away from the experience with a vivid impression of quality and professionalism. That vision is what we are trying to manifest; a mobile renewable energy trailer (see Figure 1).

Figure 1
Illustration of the Mobile Renewable Energy Trailer shown with solar panels on the roof, attractive interpretive displays, and easy walk-through access for educational trailer tours.

The fact of the matter is that a mobile renewable energy trailer would get a great deal of use and attention throughout the entire year on the HSU campus. Every ENGR 305 class would use this trailer as a laboratory for learning principles of renewable energy and appropriate technology. As a student, there is great value in being able to physically see a PV system after you have learned about one in the classroom. Such incredible principles like electricity, wire

resistance, and energy inversion right before your eyes. This trailer we propose would be a wonderful tool for students of all ages and all walks of life, to gain a different perspective about the world of electricity we as a culture so fervently depend upon.

Humboldt State is known for its progressive programs in renewable energy and carries the reputation of being a leading school in natural resource management, environmental science, and engineering. Students and professors alike on this campus have long discussed the catastrophic environmental events that are taking place today. We have searched and debated viable solutions to the devastation we have witnessed. And, we have shared our knowledge. HSU continues to keep dialog on what appropriate technology is. Our academic community has been a loud voice in the world for positive change, responsible living, and right livelihood. It is the image that HSU holds that must be reinforced with creative projects such as this mobile renewable energy trailer we propose to you now. But to carry on this project we depend your financial support – support from individuals, campus clubs, businesses, universities, and companies.

Envisioning the MRET

Other than solar power, how else will the Mobile Renewable Power Trailer (MRET) showcase renewable energy and appropriate technology? The fantastic thing about this mobile photovoltaic trailer is its versatility in demonstrating renewable energy. Inside the trailer there will be lights to illuminate the interpretive displays, which will feature compact fluorescent lighting. The PV trailer will demonstrate energy conservation in that sense. We plan on getting the most use possible out of the trailer system we create. For example, the trailer batteries could be recharged via pulling up to a wind generator or micro system and plugging in. The versatility of the trailer

Proposed Trailer Specifications

- 720watt PV Array
  (6) AstroPower AP 120 watt panels
- 720-amp/hr @ 24v battery capacity
  (8) Trojan L-16 @ 6v each with
  370-amp/hr. capacities
- Trace Engineering 2024 Inverter
  4.0 Kilowatt Sine Wave
- Equipment Mounted on a
  (6'x12'x73'') dual axel, enclosed,
  5,300 lbs max. pay load trailer

comes from its ability to inter-tie with a whole range of renewable energy technologies – bringing attention and education in nearly any application.

A Versatile Renewable Energy Education

Part of what makes this project so cool is that it can be a powerful tool for showcasing a variety of appropriate technologies. The trailer we envision has six AstroPower PV modules that would charge eight batteries. The electrical system (Figure 2) would be managed by an inverter, charge-controller, and load centers on the trailer in such a way that additional AC or DC power generating devises could be plugged into the system modularly. The electricity produced through the PV trailer system could completely power a speaker system on the HSU campus for a small public event like a school rally or live music. For larger events like HSU's annual Arts & Renewable Energy Fair, a bio-diesel generator could be plugged into the PV trailer electrical system as both a demonstration for the bio-diesel technology and an additional source of power.

Figure 2
Illustration of the Mobile Renewable Energy Trailer shown with transparent walls for viewing the battery bank, inverter, and charge controller, which are mounted in the center of the trailer.

The Schatz Energy Research Center, a research facility connected with HSU, could plug-in a demonstration hydrogen fuel cell into the power center on the PV trailer. This would demonstrate the technology of fuel cells and educate students and community members about the many different renewable energy sources can be integrated into a single system. One innovative idea is to used stationary bikes (pedaled by people), connected to ordinary car alternators, to produce yet another source of renewable energy for any number of applications.

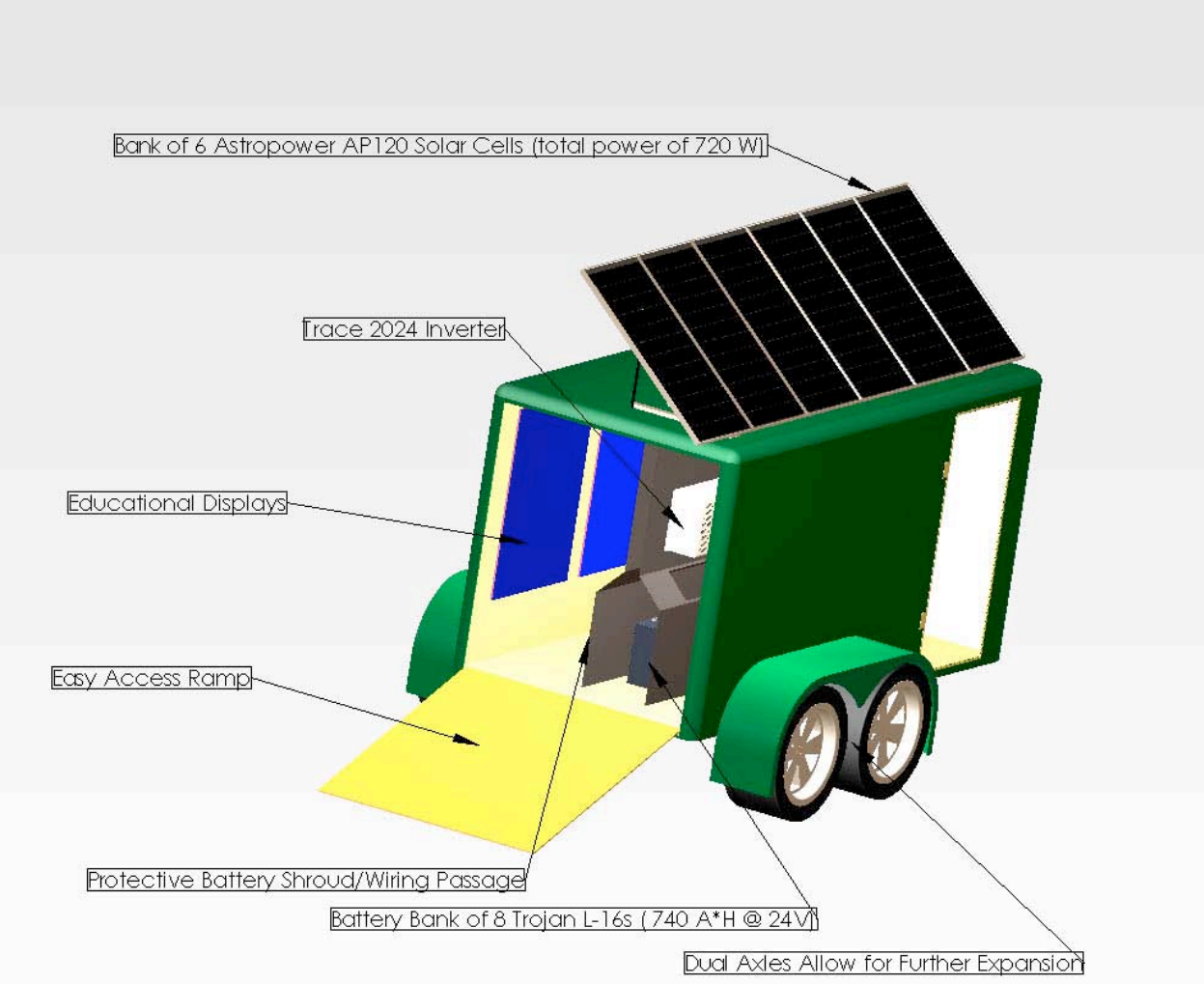


Figure 3
A 3D computer model of a dual axle trailer, which has a larger weight capacity, with an easy access ramp for people on tour to view the entire system then cycle out the side door.

A Power-full Educational Tool

People viewing the trailer would be able to walk inside and see all the components of the system this would give viewers a feel for how the whole system works together (see Figure 3 on the previous page). Interpretive displays would explain all of the components in the system such as fuses, the safety disconnect, and charge controller. Information could be handed out to people on tour of the trailer. For example, brochures, and product information could be given to students upon request so that the individual could get better acquainted with renewable energy companies and the products that are available on the market (Figure 4).

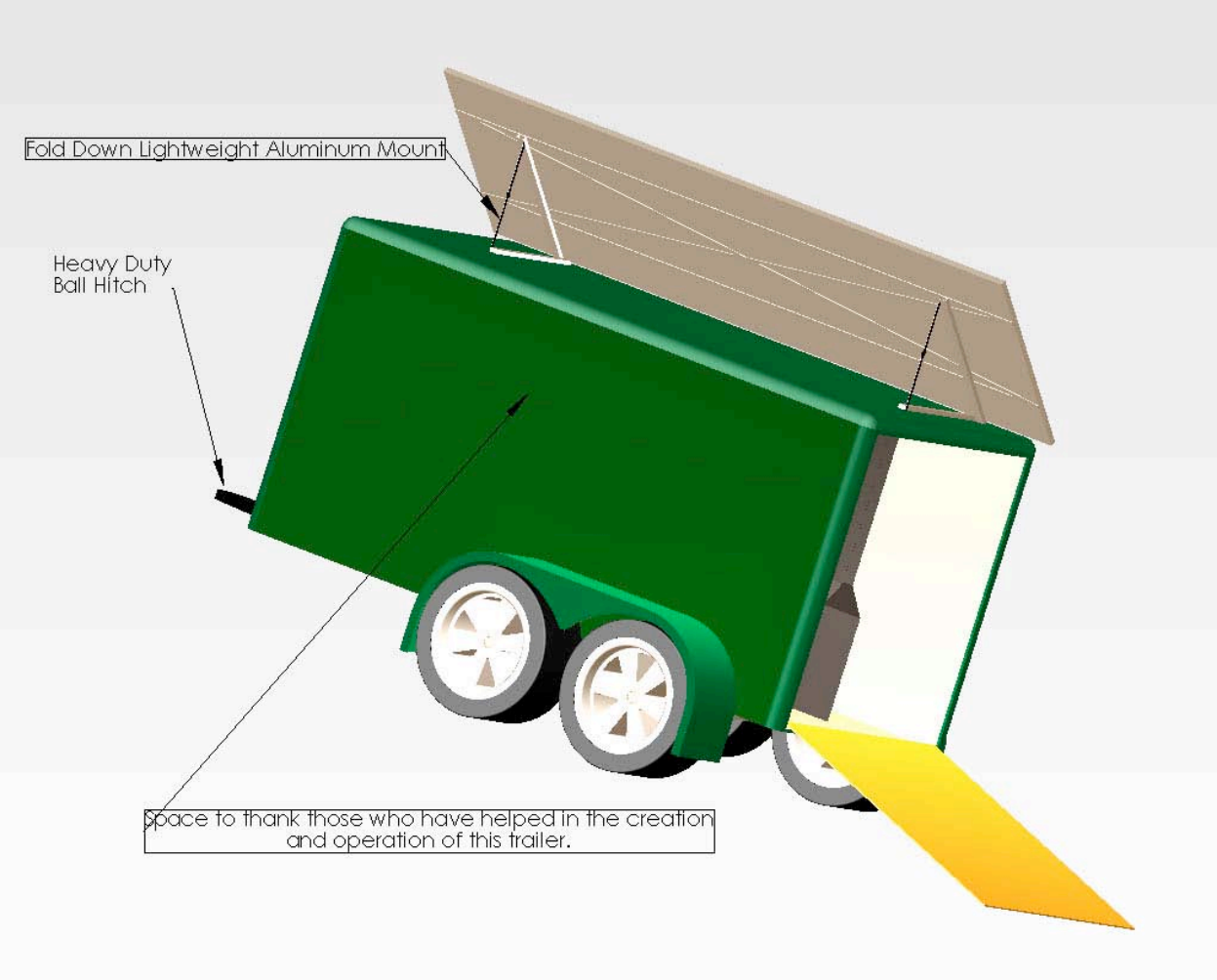


Figure 4
Again we have the MRET, this time from the opposite side. Notice how the space on the side of the trailer would serve as a perfect spot to thank our financial contributors. Also, looking from this view the PV panel rack is visible. Panels can be folded down for transport or taken off the rack for storage and security inside the trailer. The PV system will have a hitch for towing, and will require a truck capable of pulling it safely.

Interpretive displays would potentially include information on basic electrical concepts. One display might indicate the environmental cost of burning a gallon of gasoline in terms of carbon dioxide emissions into the atmosphere. Simple LED lights would be integrated into the interpretive display for interest, and to give the opportunity students to interact with the system and learn what's happening in each part.

We have been precautious in selecting a quality trailer to insure that the exterior will be weatherproof and the interior will be mold inhibiting. Since Arcata is very near the ocean, the trailer will be constantly exposed to moisture. Our group would like to see the MRET last a long time with minimum maintenance or system damage. Presumably, there will be little maintenance for the system, as PV systems are notoriously low maintenance – there are few moving parts to the system. The AP120 solar panels will require cleaning occasionally. That's about it for maintenance.

Modular Design

Another versatile feature of the design is that components within the system (i.e. batteries, solar panels) will be capable of expansion. This means that the trailer could start out with 2 solar panels and 2 batteries, if funds were limited at first, but could be upgraded to as many as 12 batteries and 12 panels. This flexibility means that the project can manifest its scale, and hence its educational impact, according to the funding or resources available.

The trailer will need a net carrying capacity of 2-3 tons to safely house and transport batteries, and all of the other system components. At full modular capacity (approximately 6-12 batteries and 6-12 solar panels) the batteries could weigh more than 2000 pounds. We are planning the sizing of the trailer based on the expectation of future modular upgrades of equipment and system output capacity.

Grid Inter-tie

Another very promising use for the proposed trailer is a grid inter-tie system. The trailer could be parked at CCAT and connected to CCAT's existing grid inter-tie system. The grid inter-tie would only be possible if PG&E approves the request. If approved, the trailer would be functional all year long – gathering energy for the Campus Center for Appropriate Technology.

Purpose

The purpose of this project is to showcase renewable energy technologies through a portable trailer, to educate students and community members about appropriate technology, to provide a renewable source of electricity for CCAT, music venues, HSU campus events, and community events, and to connect people with the information and organizations necessary to implement appropriate technologies into there own life for sustainable living.

We would like to motivate people who are interested in contributing to our sustainable energy future. People who are undecided about whether or not to "go solar" and install a grid inter-tie system may well be encouraged by our display of an operating and PV array. Also we are hoping to reach folks who do not know about solar or have negative feelings about its viability, showing them that it is a viable, clean and relatively simple way to offset much of our energy demands. With that end in mind, our goal is to make this trailer be very clean and professional in its presentation. It is important to us that the PV trailer not only be aesthetically pleasing, but also clearly communicate information about the technologies we are showing. The PV trailer will include interpretive displays describing components and how each part works within the system.

Goals & Timeline

Project Goals

This project sets forth to achieve multiple goals. Education is one goal – that education will be achieved in many ways. The project coordinators of this group are students who will be educating themselves through experiential learning. It is likely that student group members will be physically wiring the solar panels to the batteries and the inverter at some point. We'll get hands on experience by putting together the system we are designing.

Another goal is functional use throughout each year of the PV trailer's life. When the trailer is not being used at a campus event it might be able to be parked at CCAT and plugged in at the house via grid inter-tie if PG&E approval is gained. This would mean an additional supply of renewable energy to CCAT throughout the entire year. We would like the PV trailer to be energy productive all year long, even when it's not being used at an event like the Renewable Energy Fair. It follows that successful and official grid inter-tie is a goal of the MRET project.

As a goal, we would like to have the trailer completed by next years Arts & Music, and Renewable Energy Fair, which is held annually in late April.

Timeline

First and foremost, as a goal, we are seeking to acquire the necessary funding to complete this trailer project as we envision it. Our next goal upon receiving the funds we need is to begin purchasing components for the trailer that we need. Next we can begin to construct the interior structures for mounting system components. Wiring of the system can begin once mounting is completed. The PV system rack can be constructed at that point for the panel array. As a final step, all of the interpretive work can be created and installed on the trailer.

Life Cycle Responsibility for Materials

Finally, it is our goal to consider the full life cycle of the materials we are using and take as much environmental responsibility as realistically possible. Most materials will be purchased new. The parts we are proposing to purchase will not necessarily be made of recycled materials. Yet, we have designed the mobile renewable energy trailer to be durable. We expect much of the system to last for 20-50 years or more with only minor system adjustments. When parts wear out we intend to be responsible about recycling them. A good example is the batteries, which will eventually wear out, but can be recycled to the Recycling Center of Arcata.

Design Criteria & Values

- High educational value
- Showcasing a diversity of renewable energy sources
- Aesthetically pleasing
- Low Maintenance
- Clarity of communication
- Trailer Mobility
- Durability
- Clear and appropriate interpretive content
- Modular Expandability
- Safety
- Visually Attractive
- Professionalism
- Environmentally conscious design
- Reach many diverse people
- Provide quality information for visitors
- Recognize sponsors
- Connect people to renewable energy information sources
- Help learning to be fun

Budget

The Campus Center for Appropriate Technology has allocated $4000 specifically for this project. IRA via CCAT will supply additional funding for the project. It is unclear at this time how much additional funding will be granted, donated, or given to this project thorough various other sources. Manufactured PV trailers we have found have a retail price of nearly $19,000. Since our group will be responsible for all the design work and labor, we expect to complete the project for significantly less capital investment. In addition, the PV trailer project is a product of CCAT, which is a non-profit student organization, and will most likely receive significant product discounts and donations from renewable energy companies. The key for our success in building this trailer is that it be a "high profile" exhibits so that the technology is viewed for company endorsement and for public education

Proposed Expenditures

Table 1.
Itemized Expenses Spreadsheet & Parts List

No.	Part	Retail Cost	Discount %	Discount Price	Assets	Total Cost (i)	Total Cost (ii)
1	Haulmark Cub 6' Dual Axle Trailer (i)	$4,500.00				$4,500.00	$0.00
1	Haulmark Transport Single Axle Trailer (ii)	$3,300.00	20%	$2,800.00		$0.00	$2,800.00
6	AstroPower AP120 (i)	$649.00	40%	$389.40		$2,336.40	$0.00
4	AstroPower AP120 (ii)	$649.00	40%	$389.40		$0.00	$1,557.60
8	L-16 Batteries (i)	$199.00	40%	$119.40		$955.20	$0.00
4	L-16 Batteries (ii)	$199.00	40%	$119.40		$0.00	$477.60
1	Uni-Rack	$400.00	40%	$240.00		$240.00	$240.00
1	E-meter	$239.00			$239.00	$239.00	$239.00
1	Trace 2024 Inverter	$3,495.00			$3,495.00	$3,495.00	$3,495.00
1	Trace DC 175 Disconnect	$329.00			$329.00	$329.00	$329.00
2	Trace 60 Amp Aux Breaker	$40.00	40%	$24.00		$24.00	$24.00
1	Trace C-40 Charge Controller	$159.00			$159.00	$159.00	$159.00
1	Trace Fused PV Combiner Box	$229.00	40%	$137.40		$137.40	$137.40

1	15A Fuses (10-pack)	$12.00				$12.00	$12.00
1	100A DC Ground Fault Protection	$275.00				$275.00	$275.00
1	60A Main Circuit Breaker	$19.95				$19.95	$19.95
3	20A Circuit Breaker	$10.00				$30.00	$30.00
1	AC Circuit Breaker Box	$28.00				$28.00	$28.00
6	Battery Cable 4/0 18-inch	$24.95	40%	$14.97		$89.82	$89.82
1	4/O 10-ft. Cables, 2 lug pair	$125.00	40%	$75.00		$75.00	$75.00
2	Plexi-Glass (0.25" x 1.5' x 4')	$67.57				$135.14	$135.14
1	Interior Box Receptacle Plate	$0.49				$0.49	$0.49
2	Switches	$1.29				$2.58	$2.58
2	Light Fixtures	$1.99				$3.98	$3.98
2	AC Fluorescent Bulbs (32 watt)	$9.24				$18.48	$18.48
1	Exterior Outlet Box	$23.26				$23.26	$23.26
12	Bolts (2")	$0.25				$3.00	$3.00
6	Hinges (2.5")	$6.00				$36.00	$36.00
2	Steel Angle Iron (1.5"x 2"x 20')	$42.00				$84.00	$84.00
1	Tubular Steel (1"x 2"x 20')	$40.00				$40.00	$40.00
3	Surfaced 3/4" Plywood Sheets (4'x 8')	$40.00				$120.00	$120.00
10	Framing Lumber (2"x 4"x 10')	$7.00				$70.00	$70.00
1	Venting Conduit & Fittings 1.5" (20-ft.)	$20.00				$20.00	$20.00
1	Flexible Steel Conduit 12/2 (100-ft.)	$68.00				$68.00	$68.00
1	Framing Screws (2-lbs.)	$8.00				$8.00	$8.00
1	USE 10-Gauge Wire (90-ft.)	$49.50				$49.50	$49.50
1	6AWG THHN Primary Wire (20-ft.)	$13.00				$13.00	$13.00
Totals		$15,279.49			$4,222.00	**$13,640.20**	$10,683.80

Table 2.
Additional Expenses

Additional Expenses	Cost	Taxable Equipment	
Miscellaneous Construction Materials	$100	Taxable Total	$4,918.20
Quality Interpretive Displays	$300		
Transportation Costs	$100		
Printing & Graphic Design Expenses	$50		
Tax (7.25%)	$356		
Shipping (3%)	$147		
Sub-Total Expenses	$14,694		
Totals (Proposed Expenses Less Assets)	**$10,472**		

Project Funding

Table 3.
Projected Funding Source

No.	Funding Source	Availability	Retail Value	Donations	Fixed Pledge	Possible Funds	Total Funds
a.)	CCAT Trust Account	On-going			$4,000.00		$4,000.00
b.)	AS/CCAT Student Project Allocation	Spring 2003			$1,400.00		$1,400.00
							$5,400.00

Table 4.
Equipment Donations

No.	Funding Source	Availability	Item	Retail Value	Wholesale	Total Value
a.)	AstroPower, Inc.	Spring 2003	(2) AP120 PV Panels	$1,298.00	$778.80	$778.80
b.)	Trojan Battery Company		L-16 Batteries	$199.00		$0.00
						$778.80

Financial Summary

Table 5.
The Final Analysis: Fund Need

Category Breakdown	Sum Totals
Total Proposed Expenses Less Assets	$10,472.32
Total Funds	$5,400.00
Equipment Donations	$778.80
Total Acquired Funding	$6,178.80
Funding Need	**$4,293.52**

Analysis of Project Feasibility

After a detailed analysis of the myriad parts necessary for this project it is our conclusion that the financial need can be met—provided we receive additional help. $4,300 is not an excessive amount of money compared to the $17,808.18 total retail cost we would have needed to pay if starting from zilch. In that perspective, the project is well along the road to success. In fact, we are 71% of the way there – 71% of the sub-total expenses have been accounted for following our proposed budget. That leaves 29% of the money in our budget to acquire.

Trailer Debate

It should be noted that our Engineering 305 team did an extensive search (6 weeks+) for used trailers with an affordable price tag. Initially, our search was for a dual axle horse trailer. The results were disappointing considering the amount of time spent in search. Horse trailers appear to be either brand new or used to the point of disintegration. Trailers that turned up anywhere close to our price range were simply not fit for the project (i.e. excessive rust, or structurally unsound). The group consensus was that a new trailer was the best course of action, based upon our hard earned information of available used trailers within our window of opportunity. It became clear to the whole group that a new trailer was more expensive, yet had other valuable benefits. One such benefit is the overall appearance and presentation of our project. By proposing a new trailer we hope to present a more attractive finished product.

The next debate regarding the trailer is whether to choose a single or dual axle trailer. The single axle is a few thousand dollars cheaper as can be seen in "Total Cost (ii)" in Table 1. The problem with this trailer is that the equipment we will be placing on the trailer (i.e. batteries) will exceed the recommended weight capacity. We strongly recommend the dual axle trailer for safety reasons and overall durability. However, the dual axle has other inherent benefits like, more stability, easier hitching/unhitching, and more interior headroom.

Table 6.
Trailer Weight Analysis

Component	Weight Estimate (lbs.)	No.	Total Weight (lbs.)
AstroPower AP120	26.1	6	156.6
Batteries L-16	128	8	1024
Trace 4024 Inverter	115	1	115
Wire	150	1	150
PV Mounting Rack	100	1	100
Battery Box	90	1	90
Interior Mounting Board	100	1	100
Miscellaneous	100	1	100
Total Weight			**1835.6**

Table 6 shows the estimated weight of the renewable energy components we will be adding to the trailer – not to mention the people that will inside. The curb weight of the single axle (Transport Series) trailer is 1,710 pounds, compared to a curb weight of 5,140 pounds for the dual axle (Cub 6') trailer. The extra weight capacity would allow for future incremental system size increases for the trailer solar electrical system. We could choose the single axle trailer, but then we would have to downsize the system significantly (4 batteries, 4 panels), which would in turn compromise our original goal of powering a musical event so that the trailer can continually be a high profile exhibit for the school and community. Please to the specs sheets in the Appendix for more information regarding the two Haulmark brand trailers we have selected for this project.

Figure 5.
Haulmark Cub 6' (dual axle) Trailer

Funding

This MRET project will be funded through multiple sources. Allocated funding through CCAT for the trailer originated from the Green Mountain Energy Company, Redwood Alliance, and through Instructionally Related Activities (IRA) funds. Our proposal is that the remaining funds necessary for project completion be funded through donation from the Arcata Community, the renewable energy industry, and Humboldt State University. Perhaps a fundraiser could be organized for the last few hundred dollars if there was a small outstanding balance.

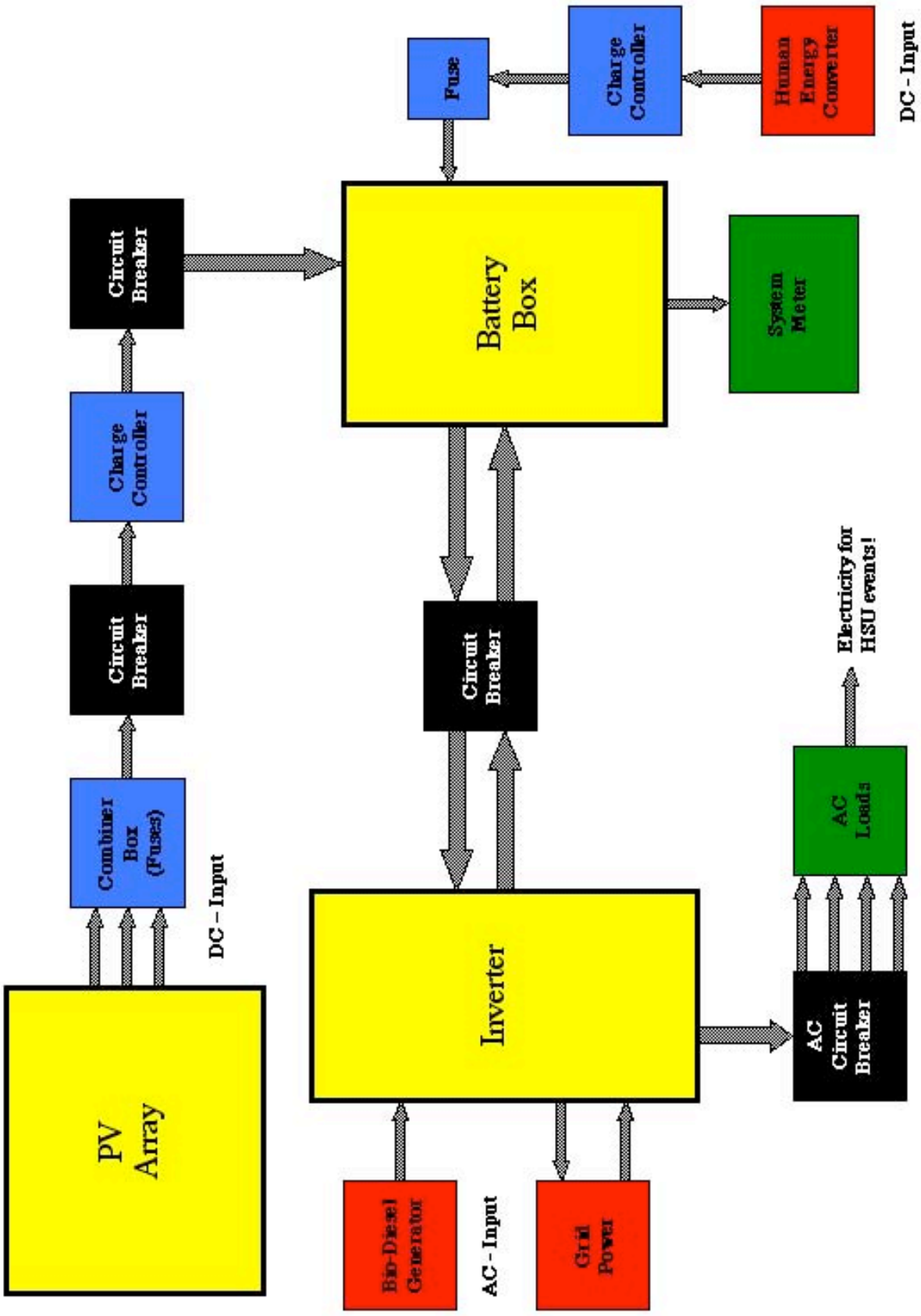
All contributors/sponsors will be equally recognized within the PV trailer display. By recognizing contributors (i.e. company name, logo) and showcasing their technologies we will be advertising for them. Advertisement in this case is another important component in the educational function of the trailer because featuring renewable energy products and the companies that make them is critical for teaching other people how to integrate the technologies into their own lives. Remember, CCAT is technically a non-profit organization, so an individual contributors and businesses can receive tax credit.

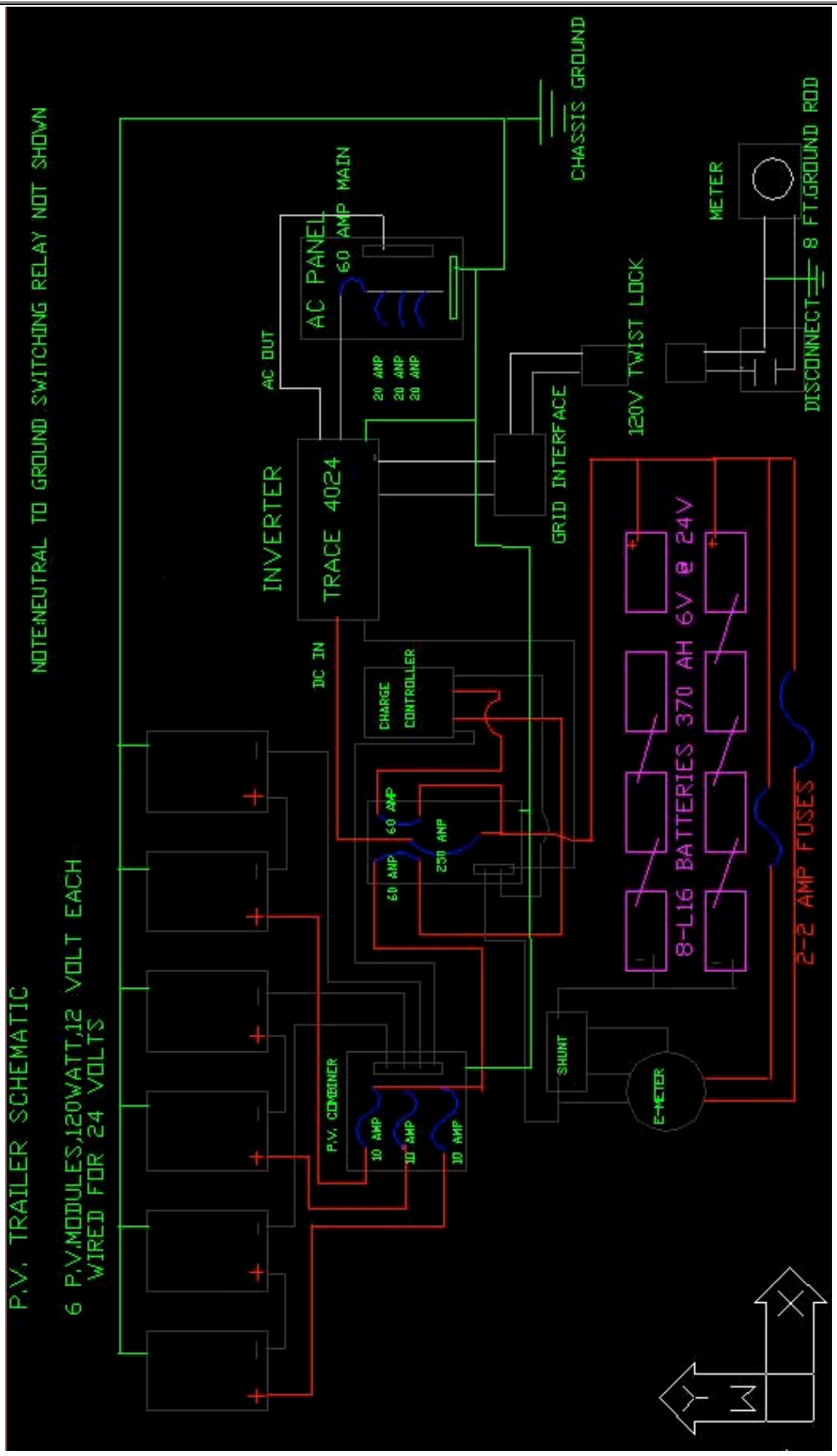
Electrical Power System

One nice feature about this Mobile Renewable Energy Trailer is that all electric components would be compliant to the standard electrical code. Students would get to wire the system together for education under close supervision of professionals.

Table 7.
Wire Sizing

Wire Path	Run (ft.)	Specifications	Wire Size No.
PV Panels to Combiner Box from 3 sets of Panels	11	33.8 VDC, 7.7 Isc	10
Combiner Box to Batteries	12	33.8 VDC, 23.1 Isc, 60A Breaker	4
Batteries to Inverter through 2 sets of 4 Batteries	9	24 VDC, 4 Kw Inverter	4/0
Inverter to AC Load Center	5	120 VAC, 60A Breaker	6
AC Load Center to 3 AC Load	10	120 VAC, 20A Breaker	12


PV Array
Combiner Box (Fuses)
DC – Input
Circuit Breaker
Charge Controller
Circuit Breaker
Fuse
Charge Controller
Human Energy Converter
DC - Input
Battery Box
System Meter
Circuit Breaker
Inverter
Bio-Diesel Generator
AC - Input
Grid Power
AC Loads
Electricity for HSU events!
AC Circuit Breaker


P.V. TRAILER SCHEMATIC
6 P.V.MODULES,120WATT,12 VOLT EACH
WIRED FOR 24 VOLTS
NOTE:NEUTRAL TO GROUND SWITCHING RELAY NOT SHOWN
INVERTER
TRACE 4024
AC OUT
AC PANEL
60 AMP MAIN
20 AMP
20 AMP
20 AMP
CHASSIS GROUND
METER
DISCONNECT
8 FT.GROUND ROD
120V TWIST LOCK
GRID INTERFACE
DC IN
CHARGE CONTROLLER
60 AMP
60 AMP
230 AMP
P.V. COMBINER
10 AMP
10 AMP
10 AMP
SHUNT
E-METER
8-L16 BATTERIES 370 AH 6V @ 24V
2-2 AMP FUSES

Additional Considerations

Towing

The PV trailer will most likely require a Humboldt State University vehicle to tow it. Perhaps a private individual with proper licensing, insurance, and capable vehicle could also tow the PV trailer to the necessary location for use.

Storage

We propose that the MRET be stored on site at the Campus Center for Appropriate Technology.

Future Project Management

If we the students of Spring Semester 2003 are unable to complete the project this semester, we will leave the project to the responsibility of CCAT to manage until completion. At that point, future Engineering 305 students could complete the project through additional CCAT funding, or external funding if necessary if the project is stalled.

CCAT will be responsible for facilitating contact with sponsors. AstroPower has specifically requested that they receive periodic updates regarding the project. Contact:

Jenn Crouse
Assistant to SVP and CFO
Investor Relations
Corporate Donations Committee
AstroPower, Inc.
300 Executive Drive
Newark, DE 19702

302-366-0400 x-1265
302-368-6087
jcrouse@astropower.com
www.astropower.com

We suggest in this proposal that the Campus Center for Appropriate Technology at Humboldt State University own the PV trailer. Also, CCAT should take responsibility for the maintenance and care of the trailer. We suggest that CCAT be responsible for tending to the

public utility relationship with PG&E through correspondence and communication for the grid inter-tie function of the PV trailer, but only if PG&E approves such an agreement. Perhaps Humboldt State University itself should be responsible for any liability regarding the Mobile Renewable Energy Trailer.

Bi-Lingual & Handicap

Are bi-lingual considerations being taken into account, and is handicap access being considered? Where appropriate interpretive signs and displays will be written in both English and Spanish. We are planning to have ramp access to the inside of the trailer. This ramp access may or may not accommodate wheel chairs and/or handicap citizens, although the overall presentation of the PV trailer will be accessible to all. This means that even if a citizen could not get inside the trailer physically, it would possible to view the main components of the system without going inside.

Conclusion

This is a good project that will address world-wide energy use, will be a great tool for education, will help the image of HSU in establishing the campus on the forefront of the energy issues in the world. This project is a wonderful opportunity for learning. CCAT has ample student interest in projects to keep this project afloat and maintained in years to come. Dear reader, we urge you to support this trailer project; it'll help a lot of people in their educational process. It'll inspire a lot of people who need the hope that such renewable energy solutions are possible.

Appendix One: Cub 6' Specs

Haulmark Trailer Specs

Cub 6' Series	Specifications
Model	GC6X12DT2
Overall Length	16'
Width	92"
Height	92"
Interior Length	12'4"
Width	69"
Height	73"
Platform Height	20"
Torflex EZ Lube Axles	tandem
Quantity	7000
Total Capacity	drop
Type	4 wheel
Brakes	electric
Tire Size	ST205/R15
Tire Load Range	15"
Wheel Bolt Pattern	C
Hitch Ball Size	5 - 4 1/2
Hitch Height to Top of Ball	2 5/16"
Hitch Weight	20"
Curb Weight	190
GVWR	1860
Payload Capacity (Avg.)	7000
Rear Doors Std.	5140
Opt.	double

Camlocks	ramp*
Rear Opening Dbl Door	yes
Ramp Door	61 1/4"
Height	63"
12V Female/Male Connec.	66"
ABS Front Cap	7 way
Prefinished Aluminum Skin	yes
Interior Walls	0.03
Floor	3/8" ply
Front Jack	3/4" ply
DOT Lighting/Dbl Bulb	yes
Safety Chains and Hooks	yes
White Spoke Wheels	yes
Aluminum Fenders	yes
Breakaway Kit	yes
	yes

Appendix Two: Transport Series Specs

Haulmark Trailer Specs

Transport Series	Specifications
Model	TS6X12DS2
Overall Length	15' 4"
Width	92"
Height	86 1/2"
Interior Length	12' 2"
Width	69"
Height	65"
Platform Height	20"

Axle Type	spring
Quantity	single
Capacity	2,990 lb.
Brakes	none
Hubs Type	idler
Tires Type	drop
Size	bias ply
Wheels Type	ST205/75D14
Ball Hitch Size	14"
Ball Height to Top of Ball	white spoke, steel
Hitch Weight	2"
Curb Weight	20"
GVWR	180
Payload Capacity	1,280
Rear Doors Type	2,990
Opening Width	1,710
Opening Height	double doors
Lock	61"
Side Door Type	60"
Width	cam lock
Height	32"
Lock	32"
12V Female/Male Connector	56"
Interior Floor	bar lock
Aluminum Fenders	4 way
ABS Front Cap	5/8" plywood
DOT Lighting/Dbl Bulb	yes