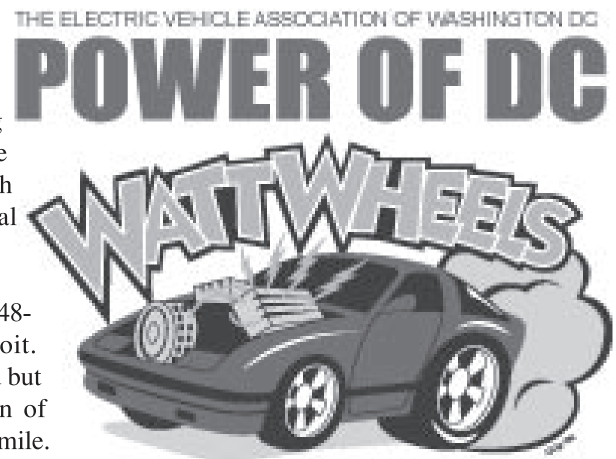
Electric Auto Association

CURRENT EVENTS

September-October 2004 Promoting the use of electric vehicles since 1967 Vol. 36 No. 9 & 10

SPARKS FLY AT THE 2004 POWER OF DC



By Chip Gribben, NEDRA & EVA/DC
futurev@radix.net

Sparks were flying and records falling at the 2004 NEDRA Power of DC Race Saturday in Hagerstown, Maryland with nine vehicles racing and 4 unofficial NEDRA records being made.

Returning this year was Darin Gilbert's 48-volt Pirahna motorcycle from Detroit. Darin broke not only a NEDRA record but his chain on his record-breaking run of 9.513 seconds at 65.513 mph in the 1/8 mile.

The track awaits

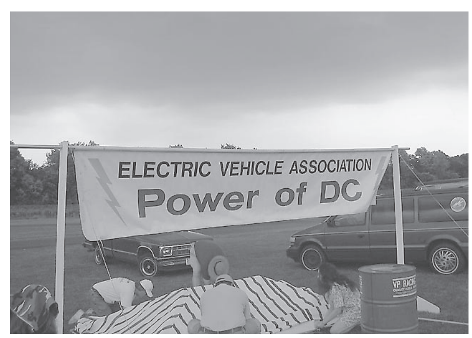
65 mph at the 1/8 is fast!! After his run, Darin knew he broke the record and was yelling "Wheeewwwww" on the way back to the pits. On a previous run Darin had everyone a little worried when his bike started wavering a bit as he was scooting back on his seat to get more aerodynamic. Fortunately, he was able to balance the bike up again.

Shawn Lawless and his family and driver Mark Moore and his family returned again with the 240-volt Orange Juice dragster from Ohio. We were hoping that NetGain could race to put a squeeze on Orange Juice but they couldn't make it. Mark drove the Orange juice superbly with straight quick runs that left the ICE crowd very impressed with a best time of 11.39 at 112 mph. The Orange Juice has some older batteries and they had some issues with low fluid in the PowerGlide tranny so they couldn't quite beat their best time last year. The Orange Juice put on quite a show during one of its burnouts when sparks began flying from underneath the dragster. Shawn decided to take the dragster out of the run to make sure everything was OK. Something had caused an arc but everything looked OK so they continued racing without any problems. They will be back again next year to take the record. Hopefully NetGain will make it down and we can have a dragster shootout. Shawn says "Bring 'em on!!"

The Central Shenandoah Regional Governor's School returned with their 120 volt 240-Z called "Sweetheart" to set a new NEDRA record for the MF/F class at 66.33 mph in 18.623 seconds. CSVRG has been with us for 4 years now from the very beginning. Next year they plan to bring two cars.

We had two new high schools making their debut this year. The Great Mills 216 volt MR-2 called the "Green Hornet" broke through the traps at 80.67 mph in 16.665 seconds with a new NEDRA breaking run for the HS/B class. The Green Hornet was a very cool looking high school team with about 6 kids and several adults traveling with the school to the race. Led by volunteer Larry Jarboe, an EVA/DC member who donating his time and resources to help the school build the car. The MR-2 had a dark green paint job with a hornet painted on the hood. What also was cool was how they rigged the lights to alternately pop up and down as they drove. The little kids who came to the race thought that was funny.

The other high school team that made its debut was Tour De Sol regular, Cinnaminson High School led by Oliver Perry with their 144 volt Ford Escort named "Olymipian". The Olympian came off with a new High School Record for the HS/E class of 24.65 seconds at 55.9 mph.



Setting up under ominous skies

Another new entry was Valerie Myers and her new teal Sparrow. Valerie is a Hagerstown local and a new member of EVA/DC. She drove her Sparrow to what I thought was a record for her class but upon further investigation she just missed the record but

continued on page 4

IN THIS ISSUE

COVER STORY

Photos and Logo provided by Chip Gribben

CE STAFF

Publications Committee:
Chairman - Ed Thorpe
E-mail: ceeditor@eaaev.org
Editors - Bob Oldham, Ed Thorpe
Publisher - Dorothy Foglia
Assistants/Reviewers - Various

News in Brief:
Electric Vehicle Today

CE Reporters/Contributors:
As noted in articles

Photo Credits:
Typically author of article, except as noted.

Calendar of Events:
E-mail: cenews@eaaev.org

Advertising Manager:
CE Advertising
E-mail: ceadvertise@eaaev.org

Article Submissions:
The deadline for articles is the first of every month for consideration in the next issue of CE. Articles received after this date will be retained for future issues of CE. Contact the Publication Committee for more information at ceeditor@eaaev.org.

Advertisements:
A full advertiser's information package and Rate Sheet can be sent by U.S. Mail or E-mail. Please contact Advertising Manager or CE Staff for details.

National EAA:
Web Site: www.eaaev.org
E-mail: contact@eaaev.org
Mailing: CE Comments
2 Smith Ct.
Alameda, CA 94502-7786, USA

Membership/Address Changes:
E-mail: membership@eaaev.org
Mailing: EAA Membership
4189 Baker Ave.
Palo Alto, CA 94306-3908, USA

www.eaaev.org

COMMENTARY: SIGN ON TO SAVE ZERO EMISSION VEHICLES!

Ford Motor Company is planning to destroy hundreds of no gasoline, zero emissions electric cars over the next several months. We need your help!

Global Exchange, Rainforest Action Network and Greenpeace are working with a broad coalition of electric car drivers to stop Ford from crushing these cars, their own great product, which delivers today what we need today—cars that offer drivers the chance to cut the ties to oil and drive emissions free.

To: William Clay Ford, Jr.

We are writing to ask you to accept the offer by Elbil Norge, a manufacturer and reseller of electric cars in Norway, to purchase your U.S. and European fleet of Th!nk City Electric Cars. The undersigned non-governmental organizations represent millions of concerned citizens.

Electric Vehicles (EVs) are one of the solutions to Ford's, and our, oil dependence. Ford has already successfully marketed these EVs, and EV drivers are both dedicated environmentalists and loyal Ford customers. Yet Ford has turned its back on the Th!nk EVs by:

1. Refusing to enable Th!nk drivers to continue driving their zero emission vehicles. The Th!nk City EVs meet European safety standards, and for three years the vehicle has received a waiver for US safety standards. Ford is refusing to petition for an extension of the waiver, which would have kept the cars in the U.S.

2. Ford is breaking its earlier promise to export the cars to Norway upon the termination of the U.S. leases. Now, Ford is has changed its mind and will not resell the Th!nk City cars in Norway.

3. Ford is ignoring the offer from Elbil Norge to purchase the entire fleet for resale in Norway.

4. Despite all of these possible solutions to preserve these cars, Ford's current intentions are to collect the EVs from their lessees and send them to the scrap yard to be crushed.

We are quite concerned about Ford's treatment of the Th!nk, Ford's most efficient car ever. The Th!nk consumes no gas and emits no greenhouse gases and is an environmental inspiration. In addition, the Th!nk is a successful product, with satisfied customers and waiting lists in both Norway and the U.S.

If Ford follows through on the plan to destroy these Zero Emissions Vehicles, Ford Motor Company would show its utter lack of concern for true solutions to reduce local air pollution and halt global climate change. The costs associated with saving the Th!nks pale in comparison with the advertising already spent on the hybrid-electric Escape SUV.

Ford faces a tremendous opportunity to avoid adverse publicity and to capitalize on environmental market trends by negotiating to sell the Th!nks to Elbil Norge for the Norwegian market. We urge you to ensure that the Zero Emission Th!nk City vehicles are resold, not scrapped.

Thank you,

Signed,
Electric Vehicle Association of Southern California
Global Exchange
Greenpeace
North Bay Electric Auto Association
Rainforest Action Network
.... and many many others!

North Bay EAA's President Nick Carter with his leased Ford City Th!nk

Background

In 2001, Ford began leasing the all-electric, super efficient "Th!nk City" cars in order to meet its obligation under the California Zero Emissions Vehicle (ZEV) mandate. Although few Th!nks were available, they were highly popular, especially among urban drivers in Los Angeles and San Francisco Bay Area. Within months, all 350 vehicles available at 5 Ford dealerships in California were leased and waiting lists developed. One hundred Th!nk City electric cars were also leased in New York as part of a NY Power Authority program. Ford announced that beginning in 2003, the Th!nk City would be available for purchase.

By 2002, every one of thousands of Zero Emission battery electric vehicles offered was successfully leased to overwhelmingly satisfied drivers, mostly in California, where state incentives for renewable energy allow many EV owners to recharge their cars using their own solar power. The cars included GM's EV1 and S10 EV pickup; Toyota's RAV4 EV; Honda's EV+; and Ford's Ranger EV pickup and Th!nk City.

In 2003, bowing to intense automotive industry lobbying and lawsuits, the California Air Resources Board eviscerated its ZEV Mandate postponing until the end of the decade the requirement for any Zero Emissions Vehicles. Upon this revision of the regulations, the automakers ceased producing electric cars, refused most requests for lease extensions, and refused all requests from leaseholders and the public to purchase the cars. Beginning in 2004, automakers have begun confiscating the vehicles in order to crush them. By 2005, if the automakers, including Ford Motor Company, have their way, nearly all the Zero Emission Electric Vehicles on the road in the USA today will be destroyed.

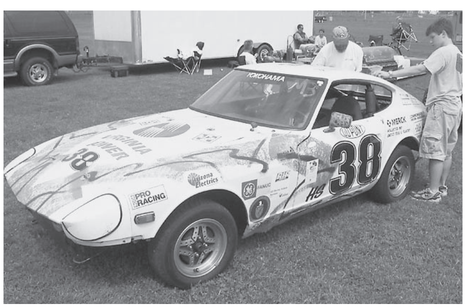
The Norwegian electric car manufacturer Elbil Norge has offered to accept all liability for the cars and repurchase them from Ford for resale in Norway, where the cars are wildly popular. To date, Ford Motor Company has refused the offer and is beginning to repossess the Th!nks in order to destroy them.

Editor note: This effort happened during August & September, resulting in some action that we plan to cover in the next issue of CE.

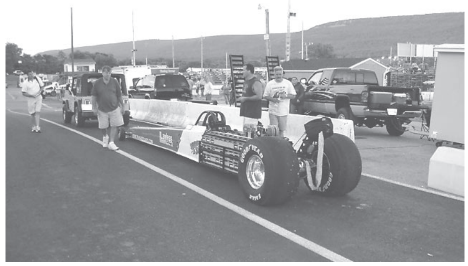
Shawn Lawless' 240V Orange Juice arrives

Shawn Lawless (right) preparing Orange Juice for another race

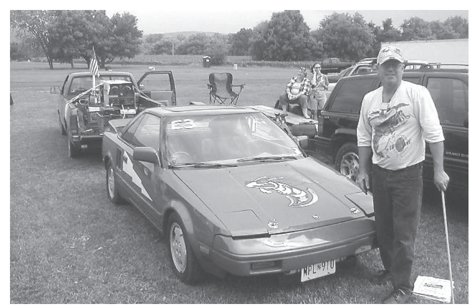
144V Cinnaminson High School's "Olympian" Ford Escort



The Shenandoah Valley Regional School 240-Z 120V "Sweetheart"



Orange Juice in the Staging Lane



Larry Jarboe with the 216V Great Mills High MR2 "Green Hornet"

she had a lot of fun. Her husband and nephews have raced on this track for years and she is starting a new trend by having her family race electric now. Way to go Valerie!!

Our local EVA/DC members also raced including Bryan Murtha and his RAV-4, Charlie Garlow in his truck and me with my Escort.

Bryan Murtha actually drove his RAV-4 EV 98 miles to the track, raced it several times at 20 seconds in the quarter mile did a quick charge and drove home all in one day. Bryan's trek is actually the longest any EV has driven under its own power to our race, raced and drove home. Which is very commendable to say the least. Good going Bryan. Bryan actually came in third place at our race for the 157 volts and up category.

Charlie Garlow brought his GM S-10 OEM conversion for the fourth year in a row. He let people drive it around the pits and raced it several times.

In addition to the racers we had many spectators from far and wide who traveled to the event.

Drew Gillet and John Walsh from the NESEA Tour de Sol came down to check out the race. I thought this was neat and interesting seeing NESEA actually interested in a NEDRA event. Wow!! They were quite friendly and interested in seeing what we were doing.

Although we had cloudy and overcast skies at the beginning and some communication discrepencies with the track on when we were to start racing it ended up being a bright sunny day and the track manager has asked us to come back again next year.

We did share the track with the gassers since it was a Test and Tune. I would say about 30 gas cars showed up so we were able to get quite a few runs in. The race started at 4:00 pm and we finished racing at 8:00 pm.

We had many folks from the EVDL and chapters of the EAA, including Mark Farver and Daniel Stewart from the Austin EAA, Bob Rice from the New England EAA, Darin Gilbert from the Motorcity EAA, Matt Graham and Shawn Waggoner from the Florida EAA, Jack Waddell, Joseph Lado, Oliver Perry, and Mike DeLiso from the Eastern Electric Vehicle Association, Jack Waddell, Mike Gollwas, Doc Kennedy, Mark Hanson, Don Berry, Frank McGrath, Roy Nutter from West Virginia University.

SPARKS FLY AT THE 2004 POWER OF DC

Valerie Myers and her 156V teal Sparrow

Checking out the WaveCrest Bike

From EVA/DC Jerry Asher, Dave Goldstein, John Clinton, Mark Powell, Al Sobel, Larry Jarboe, Dave Davidson, Greg Pokorny, Charlie Garlow, and Mike Shipway. Apologies if I left out anyone else. Please let me know if I did. I hope you all can come back again next year. We will probably have it in June again.

In addition to the NEDRA Records we gave out awards for 1st, 2nd, and third in the categories of low voltage (156 and lower), high voltage (157 and higher) and Motorcycles (all voltages).

Each winner received a cash prize, trophy, tools from Quick Cable, and books from MegaWatt Motorworks.

156 VOLTS AND HIGHER

1st PLACE
Orange Juice
DR/B
240 volts
Dragster
Driver/Owner: Mark Moore/Shawn Lawless
112 mph 1/4 mile
11.39 ET
Winnings: $200, Trophy, and a QuickCable Hex Crimper

2nd PLACE
Green Hornet
Great Mills High School
HS/B
216 volts
1985 Toyota MR2
80.67 1/4 mile
16.655 ET
Winnings: $150.00, Trophy, and a QuickCable Hex Crimper and the book Alternative Cars in the 21st Century donated by Megawatt Motorworks

3rd PLACE
Sun Power
RAV-4 EV
Brian Murtha
288 Volts
SP/A
64.65 1/4 mile
20.644 mph
Winnings: $100.00, Trophy, and a QuickCable Tool

156 VOLTS AND LOWER

1st PLACE
Sweetheart
Shenandoah Valley Regional Governors School
HM/F
120 volts
Datsun 240-Z
Driver: Coby Hausrath
66.33 mph 1/4 mile
18.623 ET
Winnings: $200, Trophy, and a QuickCable Hex Crimper

2nd PLACE
Wattson
Chip Gribben
SC/D
156 volts
1986 Ford Escort
67.12 1/4 mile
19.865 ET
Winnings: $150.00 and Trophy

3rd PLACE
Sparrow
Valerie Myers
156 Volts
SP/D
21.115 1/4 mile
56.71 mph
Winnings: $100.00, Trophy, and a QuickCable Tool

156 VOLTS AND LOWER

1st PLACE
Darin Gilbert
MT/I
48 volt Pirahna motorcycle
65.49 1/8 mile
9.513 ET
Winnings: $200.00, Trophy, and the book "El-Chopper: Complete Builder's Guide and Plans" donated by by Megawatt Motorworks

continued on page 6

SPARKS FLY AT THE 2004 POWER OF DC

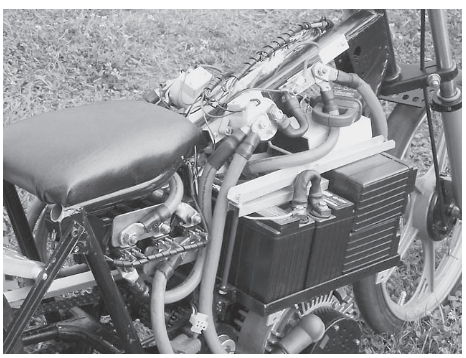
Under the hood of the Green Hornet

Tom Sigman(left) sets up the generator and panel

Inside the 240-Z cockpit

Peeling the battery cover off the Orange Juice

The Sparrow in the Staging Lane



Detail shot of the Pirahna

Charlie Garlow's 312V GM S-10

NEDRA RECORDS

Since there were two NEDRA events scheduled at the same time— Shawn Lawless suggested we have a challenge to see which event would win the most NEDRA records. I received a message from Brian Hall saying they didn't have any new records at Sonoma. We came away with 4 and here they are:

Darin Gilbert
MT/I
48 volt Pirahna motorcycle
65.49 1/8 mile
9.513 ET

Great Mills High School
HS/B
216 volts
1985 Toyota MR2 3Green Hornet2
80.67 1/4 mile
16.655 ET

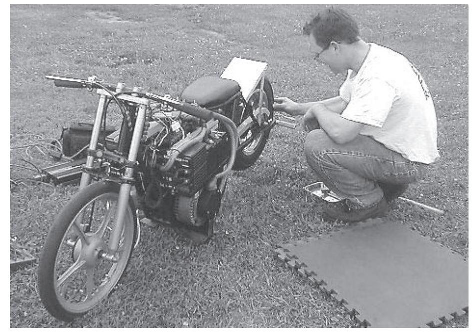
Shenandoah Valley Governor1s School
HM/F
120 volts
Datsun 240-Z 3Sweetheart2
66.33 1/4 mile
18.623 ET

Cinnaminson High School
HS/E
144 volts
Ford Escort
55.9 1/4 mile
24.65 ET

SPARKS FLY AT THE 2004 POWER OF DC

SkooterCommuter provided a WaveCrest M-750 bike for riding

Darin Gilbert's 48V Pirahna



Darin Gilbert working on the Pirahna

It was great seeing school involvement in this year's Power of DC race. We had three high schools race this year including Great Mills led by Larry Jarboe, Cinnaminson led by Oliver Perry and Central Shenandoah Valley Regional Governor's School led by Byron Humphries. And each one of them made a NEDRA record!! As a matter of fact this is CSVRG's fourth year with us and I think they have had a record just about each year at our event. We started with one school at the beginning and now have three so we are making steady progress.

We also received some good publicity for the race with the Washington Post article on Great Mill High School's story on getting prepared for the race which was an added plus.

I'd like to thank Professor Roy Nutter from the University of West Virginia for coming out. WVU wasn't able to get their car ready in time but I appreciate Roy coming out to the race. He mentioned a couple of his current students had previously raced at the Power of DC which was good to hear.

Although Brigham Young University couldn't make it with their ultra capacitor powered EV-1 because of clutch problems, it was neat that they considered coming out. Tom Erekson, the professor at BYU, was keeping us updated on their progress during testing but towards race day there wasn't enough time to allow them to fix the problems with the clutch and travel east to the race. He said they look forward to coming out next year.

I found out at the race that apparently Miramar High School from Florida was planning to come up but had technical issues with their purple Ford Probe and decided two days before the race they couldn't make it.

Power of DC Founder Greg Pokorny and son Jarod sporting PDC shirts

Matt Graham and Shawn Waggoner form the Florida EAA

Chip Gribben's daughter Jenny(r) and her cousin Meredith(l) raffeling off Suck Amps T-shirts

So although these teams couldn't make it I was pleased they thought enough of the event to consider coming out.

We'll hopefully see them and more next year. There is a whole year to get ready.

I did speak with the track manager who wants us to come out again next year. He mentioned he wants us to give him a call this fall to schedule a date and time for the next race. So around October we'll know the exact date. I'm planning for the race to be sometime in June.

I'd also like to thank the people sending pictures of the event. I'm putting a gallery together and updating both the Power of DC and NEDRA sites so when those are both ready I'll let you know.

Chip Gribben
NEDRA Power of DC
http://www.powerofdc.com

NEDRA Webmaster
http://www.nedra.com

POWER OF DC RACING PHOTOS

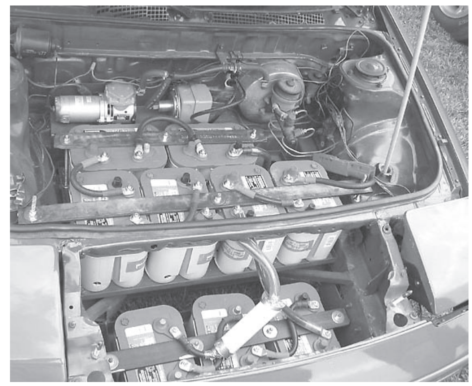
Darin in the Staging Lane

Pirahna at the starting line

A view of the juice behind Orange Juice

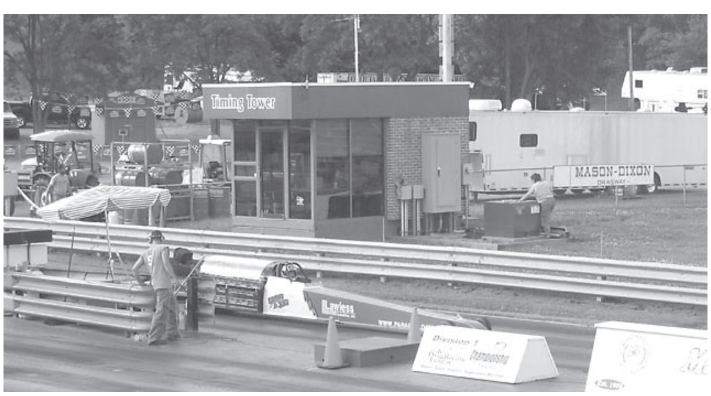
Bryan Murtha's Rav-4 vs Chip Gribben's Escort

Back of Green Hornet



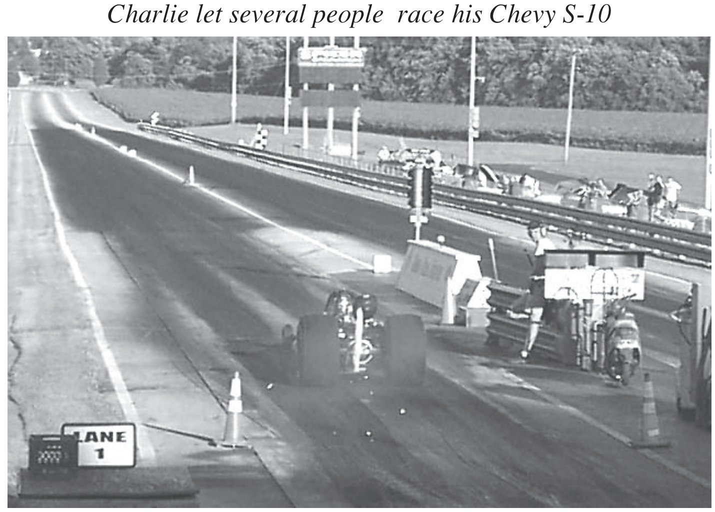
Under the hood of the Green Hornet

Dualing Ford Escorts …



Orange Juice at the starting line - Mark Moore at the wheel

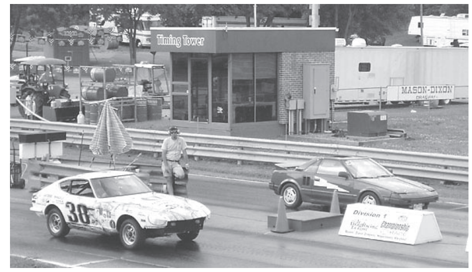
Charlie let several people race his Chevy S-10



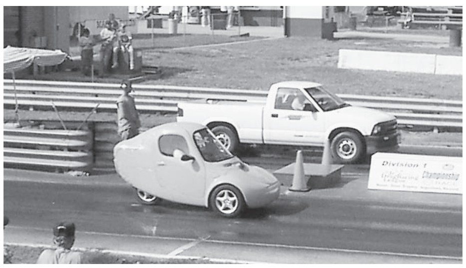
Orange Juice shooting sparks during a burnout

Bryan Murtha's Rav-4 races the Green Hornet

… and off they go

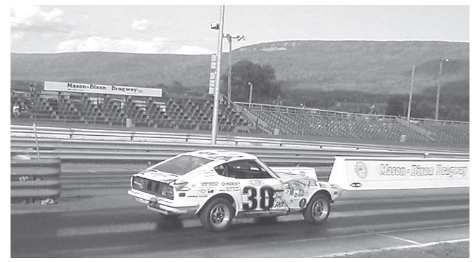


Green Hornet vs Sweetheart



Sparrow vs S-10

The Olympian vs the Green Hornet



Sweetheart takes off down the track

Stephen Eaves*, James Eaves
Eaves Devices, Charlestown, RI, Arizona State University-East, Mesa, AZ

Abstract

This paper compares the manufacturing and refueling costs of a Fuel-Cell Vehicle (FCV) and a Battery Electric Vehicle (BEV) using an automobile model reflecting the largest segment of light-duty vehicles. We use results from widely-cited government studies to compare the manufacturing and refueling costs of a BEV and a FCV capable of delivering 135 horsepower and driving approximately 300 miles. Our results show that a BEV performs far more favorably in terms of cost, energy efficiency, weight, and volume. The differences are particularly dramatic when we assume that energy is derived from renewable resources.
Keywords: Battery-Electric Vehicle; Fuel-Cell Vehicle; Well-to-Wheel; Energy Pathway

1. Introduction

Both the federal and state governments have enacted legislation designed to promote the eventual widespread adoption of zero-emissions vehicles. For instance, California enacted the Zero-Emissions-Vehicle (ZEV) program mandating automakers to claim ZEV credits for a small percentage of total vehicle sales starting in 2003. Further, the last version of the 2003 energy bill included over a billion dollars in incentives for automakers to develop technology related to Fuel-Cell Vehicles. Currently, the Fuel-Cell Vehicle (FCV) and the Battery Electric Vehicle (BEV) are the only potential ZEV replacements of the internal combustion engine, however, no studies have directly compared the two technologies in terms of performance and cost when considering the most recent advances in battery and fuel-cell technology. Below, we compare BEV and FCV technologies based on a vehicle model that is capable of delivering 100 kW of peak power, and 60 kWh total energy to the wheels.[1] This translates into a vehicle that is capable of delivering 135 horsepower and driving approximately 300 miles. The vehicle characteristics are comparable to a small to midsize car, such as a Honda Civic, representing the largest segment of the light-duty vehicle class [1].

We first compare the relative efficiency of the vehicles' well-to-wheel pathways. This allows us to calculate the amount of energy a power plant must produce in order to deliver a unit of energy to the wheels of a FCV and a BEV. Next, we compute the volume, weight, and refueling costs associated with each vehicle. We make these calculations first assuming that the hydrogen for the FCVs and the electricity for the BEVs are generated using non-fossil fuel sources. After, we relax this assumption to consider the case where hydrogen is reformed from natural gas and the electricity for BEVs is generated using a mix of fossil fuel and non-fossil fuel sources, such as wind and hydroelectric, as is the norm today.

2. Analysis and Discussion

2.1. Energy Efficiency Comparison assuming energy is derived from renewable resources

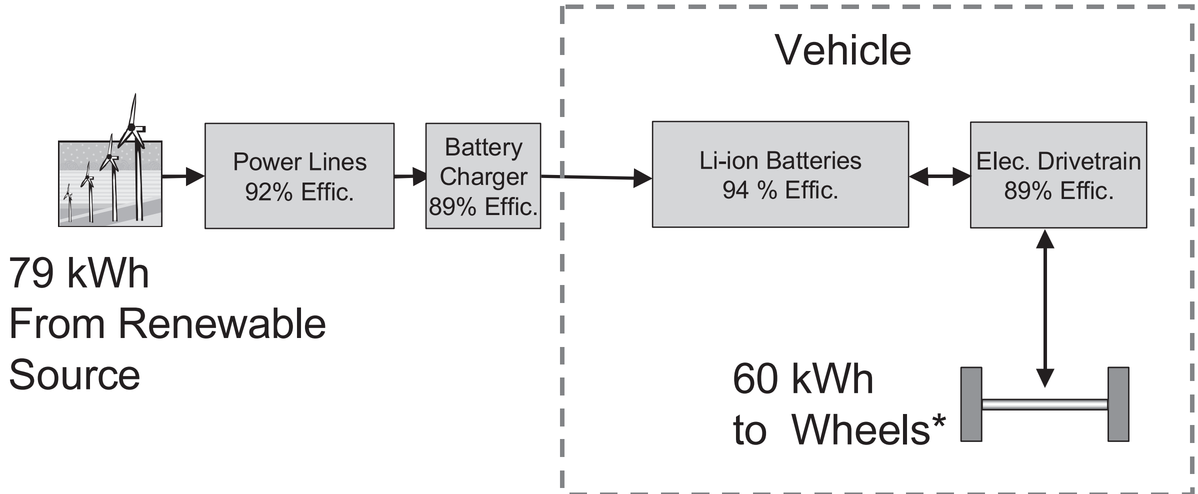
A vehicle's well-to-wheel pathway is the pathway between the original source of energy (e.g. a wind farm) and the wheels of the car. The pathwayís components are the energy conversion, distribution, and storage stages required to transport and convert the energy that eventually moves the automobile. Thus, analyzing the efficiency of each vehicle's well-to-wheel pathway allows us to determine the total amount of energy required to move each vehicle.

Fig. 1 and Fig. 2 illustrate the pathways for BEVs and FCVs, respectively. The first stage of both pathways is the generation of electricity. Since presumably we are concerned with the long-run development of a sustainable transportation infrastructure, we first assume that the electricity is generated by a non-fossil fuel resource like hydroelectric, solar, wind, geothermal, or a combination. All of these sources are used to generate energy in the form of electricity. The only established method to convert electricity to hydrogen is through a process known as electrolysis, which electrically separates water into its components of hydrogen and oxygen.

For BEVs, the electricity is delivered over power lines to a battery charger. The battery charger then charges a Lithium-ion battery that stores the energy on-board the vehicle to power the vehicleís drivetrain. In addition to one storage and two distribution stages, the BEV pathway consists of two conversion stages (the conversion of, say, wind to electricity in stage 1 and the conversion of electricity to mechanical energy in stage 2). The figure shows that the entire pathway is 77% efficient; approximately 79 kWh of energy must be generated in order to deliver the necessary 60 kWh of electricity to the wheels of the car.

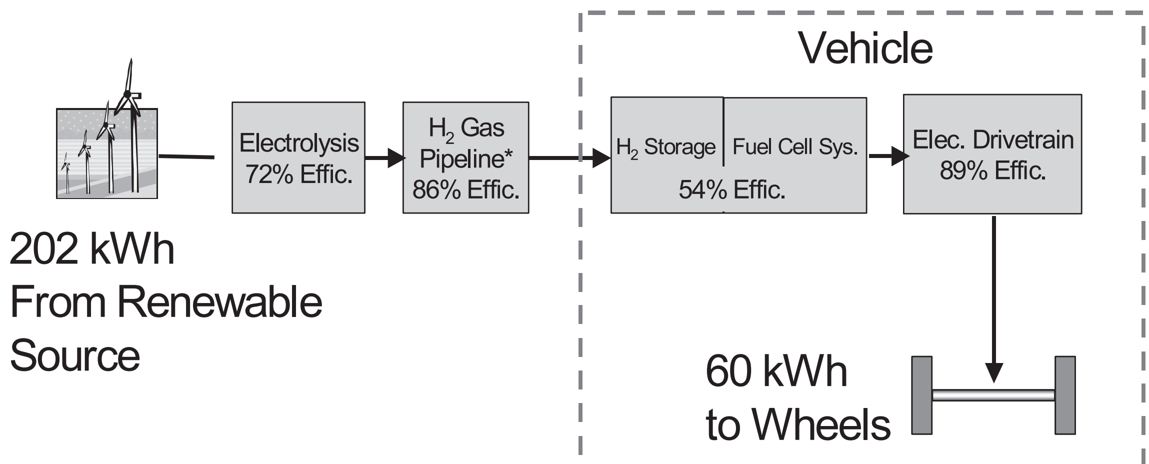
The FCV's well-to-wheel pathway, illustrated in Fig. 2, is believed by experts to be the most likely scenario, with some exceptions that are addressed below [2]. In this case, the energy from the electric plant is used for the electrolysis process that separates hydrogen gas from water. The hydrogen gas is then compressed and distributed to fueling stations where it can be pumped into and stored aboard individual fuel-cell vehicles. The onboard hydrogen gas is then combined with oxygen from the atmosphere to produce the electricity that powers the vehicle's drivetrain.

* Corresponding author. Tel.: 401-315-0547; E-mail: stepheneaves@eavesdevices.com



*The BEV regeneration capability reduces the 60kWh requirement by 6kWh while achieving the same range

Fig. 1 – Well-to-Wheel Energy Pathway for Battery Electric Vehicle



* “Pipeline” includes losses from compression, expansion, storage and distribution

Fig. 2 – Well-to-Wheel Energy Pathway for Fuel Cell Vehicle

In addition to one distribution and one storage stage, the FCV pathway consists of four conversion stages (the conversion of, say, wind to electricity in stage 1, the conversion of electricity to hydrogen in stage 2, the conversion of hydrogen back to electricity in stage 3, and finally, the conversion of electricity to mechanical energy in stage 4). Due largely to the fact that there are two additional conversion stages relative to the BEV and the fact that the onboard conversion stage is only 54% efficient, the FCV pathway is only approximately 30% efficient.[3] The result is that the pathway requires the production of 202 kWh of electricity at the plant, to deliver the necessary 60 kWh to the vehicle, or 2.6 times the requirements of the BEV pathway [3]. Obviously, this means that there would need to be 2.6 times as many wind farms or solar panels to power the FCVs versus the BEVs.

Arguably, a more efficient FCV pathway would be based on-board fossil fuel reforming or liquid hydrogen storage. However, attempts at these alternative methods have proven uncompetitive compared to a system based on compressed hydrogen gas. As a consequence, the pathway illustrated in Fig. 2 is considered by the DOE and industrial experts to be the most feasible [2].

However, contrary to our present assumption, the DOE's support for the distribution pipeline of Fig. 2 is based on the assumption of initially using fossil fuels as the source of hydrogen. In the case of renewable energy, it would be more cost effective to transport the electricity over power lines and perform the electrolysis at local "gas stations", thus eliminating the need for the expensive and less efficient hydrogen pipeline [4]. Elimination of the hydrogen pipeline stage significantly increases the overall efficiency of the pathway, however, 188 kWh is still necessary to deliver 60 kWh to the FCV's wheels, or 2.4 times the energy required to power a BEV.

The results of the non-fossil fuel analysis are impacted by the fact that we do not consider the cost of constructing and maintaining a hydrogen infrastructure. A renewable hydrogen infrastructure would consist of a network of electrolysis plants, supported by an intra-national pipeline, which, in turn, would supply a myriad of hydrogen refueling stations. The cost of hydrogen production from electrolysis is already well characterized from existing installations, but accurately projecting the downstream costs of a massive transportation and distribution infrastructure is much more difficult. The practical implication of only considering the production costs is that our estimate of the FCV's refueling cost is lower than it would be if we considered infrastructure costs. For instance, the cost of building the hydrogen refueling stations alone is estimated between $100 billion and $600 billion.[5] The U.S. Department of Energy estimates the costs of the hydrogen trunk pipelines and distribution lines to be $1.4 million and $0.6 million per mile, respectively[6]. A BEV infrastructure would be largely based on the current power grid, making its construction vastly less costly.[2]

The inefficiency of the FCV pathway combined with the high capital and maintenance costs of the distribution system results in significant differences in the refueling cost between a FCV and BEV, particularly if the source is renewable. For example, Pedro and Putsche [7] estimate that using wind energy, hydrogen production costs alone will amount to $20.76 per tank to drive our FCV 300 miles compared to $4.28 "per tank" (or per charge) for the BEV.[4]

2.2. Comparison of Weight, Volume and Cost

Maintaining the same performance assumptions, we next compare the projected relative weight, volume, and unit costs of each vehicles propulsion system. The results are reported in Table 1 and Table 2. When interpreting the tables it is important to note that the limiting factor in FCV performance is the amount of power that can be delivered, which affects vehicle acceleration and hill climbing. For BEVs, the limiting factor is the amount of energy that can be delivered, which affects total vehicle range. This means that the scaling factors for weight, volume, and cost for the FCV are based on how many Watts (of power) that can be delivered per unit of weight, volume, or cost. For the BEV it is the amount of Watt•hours (of energy) that can be delivered per unit of weight, volume, or cost.

Table 1
Estimated weight, on-board space, and mass-production cost requirements of the FCV propulsion system

Component	Weight	Volume	Cost	Reference
Fuel-Cell	617 kg	1182 liters	$23,033	ADL(2001)
3.2 kg storage tank	51 kg	215 liters	$2,288	Padro and Putsch(1999)
Drivetrain	53 kg	68 liters	$3,826	AC Propulsion, Inc.(2001), Solectria Corp (2001)
Total	**721 kg**	**1465 liters**	**$29,147**	

Table 2
Estimated weight, on-board space, and mass-production cost requirements of a BEV propulsion systems

Component	Weight	Volume	Cost	Reference
Li-ion Battery	451 kg	401 liters	$16,125	Gaines and Cuenca(2000)
Drivetrain	53 kg	68 liters	$3,826	Cuenca and Gains (1999)
Total	**504 kg**	**469 liters**	**$19,951**	

2.3. Weight Comparison

According to the DOE report on the status of fuel-cells conducted by Arthur D. Little [8], a modern fuel cell is presently capable of delivering 182 Watts of power per kg of fuel-cell. Including the required FCV drivetrain components and their losses [9,10] and the weight of the storage tank[5], a fuel-cell propulsion system capable of meeting our performance constraint must weigh approximately 721 kg. According to the National Renewable Energy Laboratory (NREL) working group report on advanced battery readiness [11], a Lithium-ion battery is capable of delivering 143 Watts•hours of energy per kg of battery. Considering an equivalent drivetrain to the one assumed for the FCV, the battery system must weigh 504 kg to satisfy our performance constraint.6

2.4. Volume Comparison

The Arthur D. Little study reports that the fuel-cell delivers 95 Watts per liter of fuel-cell, which combined with the volume of the hydrogen storage tank [12] and the volume of the electric drivetrain components produces a total volume of 1465 liters.[7] A Lithium-ion battery delivers 161 Watt•hours per liter of battery.[8] When combined with the electric drivetrain volume, this results in a total volume of 469 liters.

2.5. Cost Comparison

Finally, The Arthur D. Little study reports a cost of $205 per kW for a 100kW fuel-cell.[9] Adding to this the cost of the electric motor, control electronics and hydrogen-storage tank implies that the total cost of $29,147 for the fuel-cell propulsion system(The electric drivetrain components are $3,826 for the BEV and FCV.) [13]. For the BEV, the cost of a Lithium-ion battery is estimated to be $250/kWh [14]. Considering the electric drivetrain, this implies a total cost of $19,951 for the BEVís propulsion system.

2.6. Energy Efficiency Comparison assuming energy is derived from Fossil Fuels

Most experts are imagining that for many years to come, fossil fuels will be the main source of the hydrogen or the electricity that powers zero emission vehicles. In light of this, one should consider the near term case where the electricity for BEVs is generated using a mix of fossil fuel and non-fossil fuel sources and the FCVís hydrogen is reformed from natural gas, as is the norm today.

A 2001 study conducted for the California Air Resources Board found that when electricity for BEVs is generated using a mix of fossil fuel and non-fossil fuel and hydrogen is created from natural gas, a BEV pathway is about 8% more efficient than a FCV pathway. The study also concluded that the BEV pathway would generate lower greenhouse gas emissions. Although the efficiency comparison of the two vehicles is much closer than for the non-fossil fuel case, if the substantial cost of building and maintaining the hydrogen infrastructure necessary to support the FCV is considered, then the BEV would clearly be more attractive than the FCV. Further, if renewable energy sources will eventually replace fossil fuels, then the hydrogen pipeline would at best be inefficient, and at worst be obsolete. 7 This is because hydrogen producers would find it more economical to make hydrogen locally by using renewable electricity to hydrolyze water, rather than purchasing hydrogen transported via pipeline. Since the nationís electricity is already generated using an array of fossil and non-fossil fuel resources, the optimal design of the BEV infrastructure would not change in the conversion to a non-fossil fuel economy.

Lastly, when the non-fossil fuel assumption is relaxed, the refueling cost of a BEV is still far less than that of the FCV. Pedro and Putsch estimate the retail cost of hydrogen from fossil fuel to be $2.42 per kg [7]. Given the 3.2 kg of hydrogen necessary to meet our range-performance constraint, this results in a fill-up cost of $7.77 for the FCV.

Accounting for efficiency losses between a BEVís battery and its wheels, 64.5kWh of energy must be delivered to the BEV battery to assure that 60 kWh is delivered to its wheels. Considering a 0.89 charger efficiency and a 0.94 battery efficiency, this implies that 77 kWh of energy must be purchased from the utility company. Since BEVs will typically be charged at night, an off-peak cost of $0.06/kWh is applied for the electricity generated from a mix of fossil and non-fossil fuels. This implies a ìfill-upî cost of $4.63 for the BEV, which is about 40% lower than that of the FCV.

3. Conclusion

We use widely-cited government studies to directly compare the costs associated with producing and refueling FCVs and BEVs. The analysis is based on an automobile model (similar to a Honda Civic) that is representative of the largest segment of the automobile market. A comparison is important since the government and industry are devoting increasing amounts of resources to the goal of developing a marketable ZEV and the BEV and the FCV are currently the only feasible alternatives. We find that government studies indicate that it would be far cheaper, in terms of production and refueling costs, to develop a BEV, even if we do not consider the substantial cost of building and maintaining the hydrogen infrastructure on which the FCV would depend. Specifically, the results show that in an economy based on renewable energy, the FCV requires production of between 2.4 and 2.6 times more energy than a comparable BEV. The FCV propulsion system weighs 43% more, consumes nearly three-times more space onboard the vehicle for the same power output, and costs approximately 46% more than the BEV system. Further, the refueling cost of a FCV is nearly three-times greater. Finally, when we relax the renewable energy assumption, the BEV is still more efficient, cleaner, and vastly less expensive in terms of manufacturing, refueling, and infrastructure investment.

References

[1] U.S. Environmental Protection Agency, Light-Duty Automotive Technology and Fuel Economy Trends 1975-2001, 2001.

[2] Northeast Advanced Vehicle Consortium (under contract to Defense Advanced Research Projects Agency), Interviews with 44 Global Experts on the Future of Transportation and Fuel Cell Infrastructure and a Fuel Cell Primer, Agreement No. NAVC1099-PG030044, 2000.

[3] General Motors, Argonne National Laboratory, BPAmoco, Exxon Mobile, and Shell, Well-to-Wheels Energy use and Greenhouse Gas Emissions of Advanced Fuel/Vehicle Systems, 2001.

[4] CA Energy Commission and the Air Resource Board, A Fuel Cycle Energy Conversion Efficiency Analysis, 2000.

[5] CA Energy Commission and the Air Resource Board, A Fuel Cycle Energy Conversion Efficiency Analysis, 2000.

[6] U.S. Department of Energy, Annual Progress Report, 2003.

[7] Padro, C., V. Putsche, Survey of Economics of Hydrogen Technologies, National Renewable Energy Laboratory Study NREL/TP-570-27079, 1999.

[8] Arthur D. Little, Inc. report to Department of Energy, Cost Analysis of Fuel Cell System for Transportation, Ref. No. 49739, SFAA No. DESC02-98EE50526, 2001.

[9] AC Propulsion Inc., AC150 GEN-2 EV Power System Specification Document, 2001.

[10] Solectria Corp., DMC0645 AC Motor Controller Specification, 2001.

[11] National Renewable Energy Laboratory, Advanced Battery Readiness Ad Hoc Working Group Meeting Report 2000.

[12] Padro, C., V. Putsche, Survey of Economics of Hydrogen Technologies, National Renewable Energy Laboratory Study NREL/TP-570-27079, 1999.

[13] Cuenca, R., L. Gaines, A. V., Evaluation of Electric Vehicle Production and Operating Costs, Center for Transportation Research, Argonne National Laboratory, 1999.

[14] Gaines, L., R. Cuenca, Costs of Lithium Ion Batteries, Center for Transportation Research, Argonne National Laboratory, 2000.

Notes

[1] BEVs and FCVs with performance characteristics comparable to these specifications have been developed and tested. For instance, the Honda FCX, recently presented as one of the first commercially available fuel-cell vehicles, has a peak power of 80 HP and a maximum range of 220 miles. In August 2003, using Lithium-ion batteries, AC Propulsion produced a BEV that has a range of 250 miles at speeds of 75-80 mph and goes from 0-60 mph in about 4 seconds.

[2] Studies on EV charging infrastructure in California found that a large number of electric vehicle will not severely tax the existing power grid. In fact, the load leveling effect of the vehicles would be beneficial, see "Electric Vehicle and Energy use Fact Sheet" published by California Air Resources Board, (January 2002).

[3] The actual efficiency would most likely be significantly lower since there are "parasitic" losses from fans, pumps etc. However, since the ADL study did not separately account for parasitic losses in the fuel cell stack and fuel processor, they were conservatively not considered in this study.

[4] The cost per tank is based on the Padro and Putsche [12] estimate of $6.49 per kg to produce the 3.2 kg of hydrogen necessary to power the FCV for 300 miles and $.055 cents per kWh to provide the 77.9 kWh required to power the BEV for 300 miles.

[5] To store 3.2 kg of hydrogen the tank must be 215 liters [12] .

[6] The BEV has the ability to capture approximately 10% of the energy sent to the wheels back to the battery pack during deceleration, this is commonly known as regeneration. Accounting for the drivetrain efficiency, and 10% regeneration, 64.5 kWh must be stored in the battery to deliver 60kWh to the wheels.

[7] The electric drive train volume with a 66% packing factor occupies 68 liters for both the FCV and BEV, See AC150 GEN-2 EV Power System Specification Document, [9].

[8] Lithium-ion batteries provide approximately 230 Wh/l; a 43% packing factor reduced this to 161Wh/l [11].

[9] The study reports on a 55kW fuel cell, but also indicates that the fuel cell cost scales well with power.

True Costs of Electric Vehicles

July 2003 | **Electric Auto Association (EAA)**

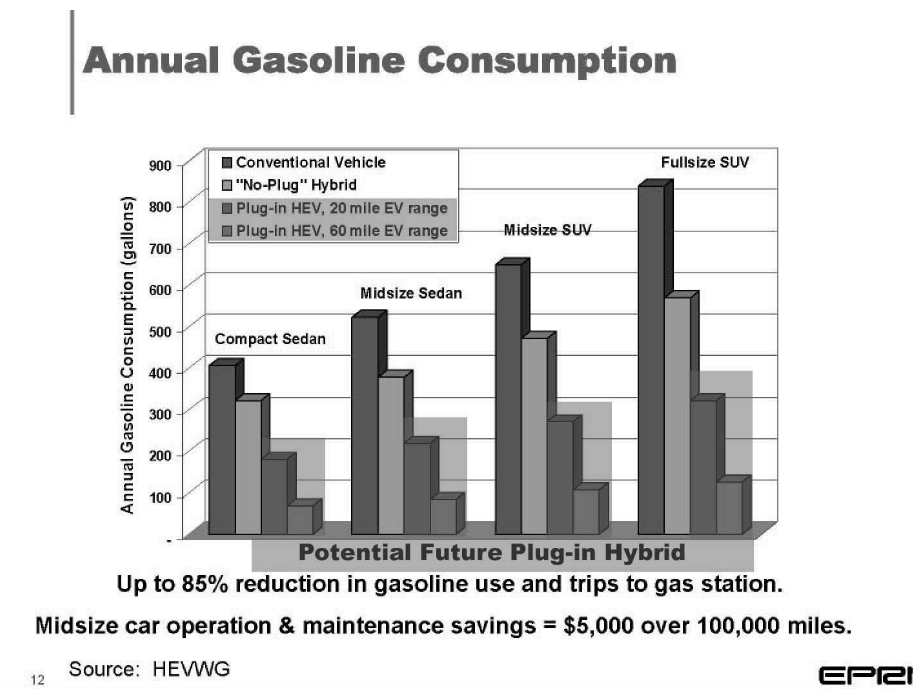
"Promoting the use of electric vehicles since 1967"

What costs to consider?

When evaluating comparable costs for vehicles, it's important to consider the total cost of ownership for a vehicle. This includes: initial purchase price and sales tax, annual insurance premiums, annual licensing/registration, annual fuel costs, and annual maintenance costs. There are additional costs to society in the form of air pollution and reliance on foreign sources of fuel, but for purposes of this discussion we will ignore them. Over the lifetime (typically 10 years) of the vehicle, fuel costs (assuming 12,000 miles/year) can be the most significant cost associated with owning and driving a gasoline powered car.

Annual Fuel Costs?

Fuel costs vary by vehicle. For purposes of comparison we will look at 4 vehicle types – compact and mid-size sedan, and mid-size and full-size SUVs [1]. Naturally, a vehicle, such as a gasoline powered mid-sized sedan will consume less fuel than a full sized truck or SUV. In addition, we'll look at conventional gasoline powered vehicles, hybrid electric vehicles (HEV) available today ("no-plug" hybrid), and future vehicles known as plug-in hybrids. Plug-in hybrids are capable of some number of pure electric (no use of gasoline or the gas engine) before gasoline and the gas engine is used. For example, an HEV-0 would be a hybrid vehicle available now (does not plug in and always needs the gasoline engine to propel the vehicle), an HEV-20 is a hybrid that plugs in and is capable of traveling 20 miles of pure electric range, and HEV-60 is capable of 60 miles of pure electric range. You'll see by the annual fuel costs below, you really do want to "plug-in your vehicle" – besides the fuel savings (electricity is significantly cheaper than gas), you will also reduce vehicle emissions.



[1] http://www.epri.com/corporate/discover_epri/news/2002releases/121102_hev.htmlw.epri.com

"EAA EV drivers have logged over 3 million clean miles"

E-mail: info@eaaev.org
Web: www.eaaev.org

Cost comparison

For purposes of comparison, let's use a mid-size sedan (these represent the safest vehicles on the road, and for a conventional vehicle, achieve good miles per gallon (MPG) rating). We will assume that maintenance for items such as: tires, brakes, air conditioning, power steering are identical for each vehicle. Consider costs for a 10 year life span of 120,000 miles. Annual maintenance includes: oil changes (every 3,000 miles) at about $35, tune-ups (every x miles) at about $300-$600, and in California, biannual smog checks at $75. We will assume cost of electricity at $0.075/kWh – a good average for California.

Remember, if the owner uses solar panels to generate the electricity, the cost of electricity would be $0.

	Mid-size sedan	**HEV-0**	**HEV-20**	**EV Conversion**	**Production EV (Rav4-EV)**
Purchase price (with 8.25% sales tax)	$23,000	$2,000 more than conventional car	Unknown	$10,000 EV conversion costs $6,000-$10,000	Production EV is roughly $10,000 more than comparable.
Insurance	$600/yr	$600/yr	$600/yr	$600/yr	$600/yr
Maint	$108/yr	$108/yr	$108/yr	New lead-acid battery pack every x miles at $1,600	Production EVs have a battery pack life of 130K-150K miles $0
Fuel: $2/gal for gas; $0.075/KwH for electricity	$1000/yr	$700/yr	$300/yr	$265/yr (probably should be cheaper than RAV4-EV) (could be $0 with solar panels)	$265/yr (could be $0 with solar panels)
Total 10-year cost	$31,080	$32,780		$17,865	$39,265

About the EAA

The EAA is a non-profit educational organization that promotes the advancement and widespread adoption of electric vehicles; organizes public exhibits and events of electric vehicles to educate the public on the progress and benefits of electric vehicle technology.

Electric Auto Association

Rev: 20030714

Electric Vehicle History

January 2004

Electric Auto Association (EAA)

"Promoting the use of electric vehicles since 1967"

1904 Curved Dash Olds (replica)

1915 Detroit Electric Automobile

Walt Disney's 1901 Oldsmobile EV

EV in 1912

Electric Van

A little background

In the late 1890s electric vehicles (EVs) outsold gasoline cars ten to one[1]. EVs dominated the roads and dealer showrooms. Some automobile companies, like Oldsmobile and Studebaker actually started out as successful EV companies, only later transitioning to gasoline-powered vehicles. In fact, the first car dealerships were exclusively for EVs.

Early production of EVs, like all cars, was accomplished by hand assembly. In 1910, volume production of gasoline powered cars was achieved with the motorized assembly line. This breakthrough manufacturing process killed off all but the most well-financed car builders. Independents, unable to buy components in volume died off. The infrastructure for electricity was almost non-existent outside of city boundaries – limiting EVs to city-only travel. Another contributing factor to the decline of EVs was the addition of an electric motor (called the starter) to gasoline powered cars – finally removing the need for the difficult and dangerous crank to start the engine. Due to these factors, by the end of World War I, production of electric cars stopped and EVs became niche vehicles – serving as taxis, trucks, delivery vans, and freight handlers.

In the late 1960s and early 1970s, there was a rebirth of EVs prompted by concerns about air pollution and the OPEC oil embargo. In the early 1990s, a few major automakers resumed production of EVs – prompted by California's landmark Zero Emission Vehicle (ZEV) Mandate. Those EVs were produced in very low volumes – essentially hand-built like their early predecessors. However, as the ZEV mandate was weakened over the years, the automakers stopped making EVs – Toyota was the last major auto maker to stop EV production in 2003.

Timeline

1834: Thomas Davenport invents the battery electric car – batteries were not rechargeable.

1859: Gaston Plante invented rechargeable lead-acid batteries.

1889: Thomas Edison built an EV using nickel-alkaline batteries.

1895: First auto race in America, won by an EV.

1896: First car dealer – EVs.

1897: First vehicle with power steering – an EV. Electric self-starters 20 years before appearing in gas-powered cars.

1898: NYC blizzard, only EVs were capable of transport on the roads. First woman to buy a car – it was an EV.

1900: NYC's huge pollution problem – horses. 2.5 million pounds of manure, 60,000 gallons of urine daily on the streets; 15,000 dead horses removed from the streets each year.

1900: All cars produced: 33% steam cars, 33% EV, and 33% gasoline cars.

1903: First speeding ticket – it was earned in an EV.

1904: America has only 7% of the 2 million miles of roads better than dirt – only 141 miles, or less than one mile in 10,000 was "paved".

1908: Henry Ford buys his wife an EV. Many socialites of that time gave this rousing endorsement for EVs, "It never fails me."

1 Sources for materials presented here EAA historical archives, "The Electric Vehicle and the Burden of History," David A. Kirsch. "The Lost Cord: The Story Tellers History of the Electric Car," Barbara E. Taylor. "Taken for a Ride," Jack Doyle

"EAA EV drivers have logged over 3.4 million clean miles"

Walter Laski, EAA Founder

Bob Beaumont w/CitiCar

GMEV-1

Toyota RAV4-EV

Toyota Prius Hybrid

E-mail: info@eaaev.org
Web: www.eaaev.org

Rev: 20040131

1910: Motorized assembly produces gas-powered cars in volume; reducing cost per vehicle.

1912: 38,842 EVs on the road. Horse drawn "tankers" deliver gasoline to gas stations.

1913: Self starter for gas cars (10 years later for the Model-T).

1921: Federal Highway Act. By 1922, federal match (50%) for highway construction and repair (for mail delivery). Before this, roads were considered only "feeders" to railroads, and left to the local jurisdiction to fund.

1956: National System of Interstate and Defense Highways. Funded 90% by states, and 90% by the federal government.

1957: Sputnik is launched. The US space program initiates advanced battery R&D.

1966: Gallup poll: 36 million really interested in EVs. At the time EVs had a top speed of 40 mph, and typical range less than 50 miles.

1967: Walter Laski founds the Electric Auto Association.

1968-1978: Congress passes more regulatory statues than ever before due to health risks associated with cars: collisions, dirty air.

1972: First Annual EAA EV rally.

1974: CitiCar debut at Electric Vehicle Symposium in Washington, DC. By 1975, Vanguard-Sebring, maker of the CitiCar is the 6th largest auto maker in the US.

1990: California establishes the Zero Emission Vehicle (ZEV) Mandate; requires 2% of vehicles to be ZEVs by 1998, 10% ZEVs by 2003.

1990: GM shows their production EV initially named, Impact; later it was re-named the EV-1.

1990: US government spent $194 million on all energy efficient research. Much less than the $1 billion for a single day of Desert Storm, or the $1 billion per week of 2003 Iraq conflict.

1993: GM estimated that it would take 3 months to collect names of 5,000 people interested in the EV-1 – it only took one week!

1995: Renaissance Cars, Inc begins production of the Tropica.

1996: EAA helps to hatch CALSTART incubator (for EV research) in Alameda, CA.

1996: GM begins production of the EV-1 (formerly called the Impact).

1997: Toyota Prius hybrid gas-electric vehicle unveiled at the Tokyo Auto Show.

2002: Toyota RAV4-EV retail sales; their estimated 2-year supply sold out in 8 months.

2003: ZEV Mandate weakened to allow ZEV credits for non-ZEVs. Only requires 250 fuel-cell vehicles by 2009. Toyota stops production of the RAV4-EV; Honda stops lease renewals of the EV-Plus; GM does the same for the EV-1.

2003: 31st Annual EAA EV Rally in Palo Alto, CA. featuring over 30 vehicles: EV conversions, production EVs, hybrids, and personal EVs.

2003: AC Propulsion's tZero earns highest grade at the Michelin Challenge Bibendum; tZero specs: 300 miles per charge, 0-60mph in 3.6 seconds, 100 mph top speed.

About the EAA

The EAA is a non-profit educational organization that promotes the advancement and widespread adoption of electric vehicles; organizes public exhibits and events of electric vehicles to educate the public on the progress and benefits of electric vehicle technology.

SUBARU R1e

By Michelle Krebs, cars.com

The R1e is a pure electric vehicle with batteries developed by Subaru and NEC Corp.; these batteries are also used in the Subaru B9SC gasoline/electric hybrid concept. They can be charged by plugging them into the type of AC outlet used for large residential air conditioners.

The R1e is a small car with a 2+2 seating configuration designed to appeal to single people or couples in urban markets. It debuted at the 2003 Tokyo Motor Show and was shown in the United States for the first time at the 2004 North American International Auto Show in Detroit.

Photographed by Casey Spring, cars.com

Top: Subaru R1e concept front angle

Above Left: Inside is a 2-plus-2 seating configuration

Above Right: The diminutive R1e is designed for an urban setting

Left: The car's power comes solely from electricity

http://www.cars.com/go/features/autoshows/

CONSTRUCTION OF A HIGH POWER ELECTRIC BICYCLE (CONTROLLER)

By David Kronstein, VEVA
(tesla500@hotmail.com)

Reprinted from the Feb 2004 VEVA newsletter

I started this project in early summer 2002, with the goal of creating a fun, powerful, and cheap PEV that would not need a license to operate. This meant that the vehicle had to look similar to a bicycle, so I went with the obvious choice and used my dad's old mountain bike as the base vehicle. This old bike is well built, with a frame made of thick wall round steel tube, and has lots of attachment points to mount things to without welding to or drilling holes in, and thus weakening, the frame.

Modern mountain bikes are usually built with thin oval section tubes that are a poor choice for a heavy EV, not only because they are weak, but also because they take up a lot of space inside the triangular frame where batteries and motor controller have to be mounted.

The hardest decision of this project was what motor to use. To get the performance I wanted, I knew I would need a motor capable of at least 3HP peak. The motor also had to be relatively light, and this immediately ruled out most motors. After searching for a while, I found three prospects; the Scott 4BB-02488, the Briggs and Stratton E-Tek, and the eCycle MG13.

The Scott 4BB-02488 is rated 1HP continuous, 3.5HP peak, and costs $400.

Other than the no-load speed of 3,300 RPM, this motor is perfect. To get a top speed of 45KPH, the 26" bike wheel needed to spin at 360 rpm, which would have required a two-stage reduction. The high no-load speed dictated a toothed belt first stage to keep the noise down, and would be large, expensive, heavy, and difficult to construct without a metal lathe.

The Briggs and Stratton E-Tek run on 24V has a continuous power of approximately 2HP, a peak power of 3.75HP, and costs $600. This motor is relatively large, heavy and expensive, but has two advantages over the Scott motor. First, it has a no-load speed of 1700rpm, meaning a single stage reduction would be practical for my bike. Second, this motor can be used on other, larger vehicles because of its ability to run on a higher voltage and produce more power.

The eCycle MG13 is a brushless DC pancake motor designed for 24-48V. Except for one thing, this motor is perfect. It's relatively small, light and (was at the time) cheap. At 24V, the no-load speed is 1725 rpm, perfect for my bike. Power is certainly not lacking at 7HP peak. The pancake design of the motor is perfect to fit over the rear wheel and not get in the way of anything. But all these benefits were outweighed by the lack of a proper controller. The stock controllers are extremely expensive, about $1,200, and can only deliver 100A. I could have built a controller, but at the time I had little experience and didn't want to take such a risk.

All options carefully weighed, I chose the E-Tek. It's combination of low speed, high power, usability in future projects and ease of control were best for my bike.

With the motor chosen, it was time to think of the electronics. From the beginning, I knew I was not going to spend half the project's budget on a motor controller. I had built several small motor controllers before, but nothing this large.

I decided on 24V, 400A peak and 150A continuous as the ratings for the controller. After a look through the Digi-Key cataloge, I settled on 6 IRF1404 MOSFETS and a 240A Schottky diode for the power section.

The control section was a basic triangle wave generator and comparator circuit to generate the PWM signal for the mosfet driver. There was originally going to be a current limiter based on motor speed, but I abandoned that early on.

All the parts were mounted in a standard plastic project box, measuring approximately 18cm x 10cm x 6cm. The MOSFETs and Diode were mounted on separate extruded aluminum heatsinks, which also functions as conductors. The internal power connections were made with aluminum bar and #8 wire.

Reliability was paramount for this controller. MOSFETs usually fail short circuit, and this could cause the vehicle to flip over backwards from the acceleration. To prevent this, both the MOSFETS and the Diode are protected with zener clamps and RC snubbers to prevent damage due to high voltage spikes. This design has proven to be extremely reliable, with no component failures to this day.

Batteries were the next thing to be decided upon. To achieve a long range, a large battery capacity is necessary. Two single batteries of sufficient size were out of the question, as there was no room on the bike to mount them. To overcome this, multiple parallel batteries had to be used. I decided on 3 parallel sets of two Panasonic 12V 17AH SLA batteries in series. Hawker batteries would have been preferable, but were too expensive.

With the electronics and motor out of the way, it was time to decide how to get the power to the wheel. Running a chain from the motor to the rear cassette was impractical due to the required reduction required and the weakness of the chain. Gearing the motor down sufficiently to drive the crank was not practical either, because such a gearing system would be extremely difficult to build. The other options were a friction drive system, which was out of the question, and a second drive chain on the opposite side of the wheel as the cassette. I of course chose the latter.

I decided on a gearing of 14-60 to attain a top speed of 45 km/h. This was chosen based on the motor's performance curve, the wheel diameter and a rough estimate of how much power would be required to move the vehicle at top speed. My original plan was to use a #35 (3/8" pitch) chain, but I was unable to obtain a 60-tooth sprocket of that pitch. I had to use #40 (°" pitch) chain.

Mounting a sprocket on the opposite side of the wheel as the derailleur was not an easy task. Eric Peltzer accomplished this on his bike, but it required access to a metal lathe, and the result was not as robust as I would have preferred for the amount of torque I wanted to transmit. I eventually came up with the idea of using a hub designed for a disc brake, installing a sprocket in place of the disc. This simple solution quickly became more complex, because it was impossible to mount the sprocket directly to the hub due to lack of clearance between the sprocket and the bike frame. To get enough clearance, I had to make an adapter to move the sprocket toward the center of the wheel. This adapter consisted of an aluminum plate with two sets of holes, near the center and near the edge.

The center holes are for bolts to mount the plate to the hub, while the outer holes have bolts that go through a set of washers to space the sprocket back. The sprocket has a hole in the center cut to a shape that matches the cross section of the hub to help transfer torque more directly.

Now it was time to design the battery and motor mounts. The design ad to be easy to build, requiring only basic metalworking tools, and cheap. Thus I chose angle and flat cross-section steel for the mounts. This material is easy to work with, yet strong.

The mount for the batteries that go on each side of the front wheel was made with three pieces of flat steel welded into an inverted "U" shape that goes over the wheel. Plates welded to this frame support the batteries, which are held in place on the plates with rectangular shaped steel rings. The top of the frame is supported with two pieces of flat aluminum, one going to the top of the fork and the other going to the handlebar to take some stress off of the fork while braking.

The center battery mount is extremely simple, comprised of one piece of angle iron and two flat pieces of steel welded to another flat piece, which attaches to the bike. The angle piece is on the low side of the mount and stops the batteries from sliding out. Gravity and the bike frame top tube stop the batteries from sliding out the other way, and a steel support stops the batteries from coming out of the top of the mount.

The rear battery mount is similar to its counterpart in the front. It's comprised of three pieces of angle iron welded in the same inverted "U" shape as the front mount. The battery supports are also similar to the ones in the front, but are more robust. The batteries are held in by angle iron running up the outside corners, with another piece of flat steel to support the tops of the angle iron and stop the batteries from coming out the top of the mount. The top of the frame is held in place by the motor mount.

On top of the rear battery frame is the motor mount, which is made up of angle iron welded into a rectangular shape. One piece is longer than the others to facilitate mounting. This protruding piece attaches to an angle iron adapter that attaches to the bike frame, and allows the motor mount to pivot up and down to adjust chain tension. A bolt extends from the center of the motor mount down through a hole in the top of the rear battery mount and allows chain tension to be adjusted.

The power switch is a four-pole double throw unit rated at 25A 120V AC. I had done tests with old computer power supply switches and found that a 15A switch can easily handle 100A for a few seconds, so I was not worried about the switch failing. With the six-battery set-up, one pole was used for each parallel string, thus isolating them when the power was off. This switch is mounted in a box on the handlebars, along with a charging connector and capacitor precharge switch and resistor.

With all the components now in place, it was time to wire everything up. I chose #8 wire to connect the parallel strings of batteries to the switch, and #4 for everything after the switch. I used ultra fine strand speaker wire, normally used in high performance car audio systems.

The last thing to be completed was the throttle. I used a twist grip designed for an ICE, with an adapter to convert the pull of the cable into a 270° rotation of a potentiometer.

The first test ride was quite an experience. I had the cover (which has the cooling fan on it) off the controller so I could check for overheating.

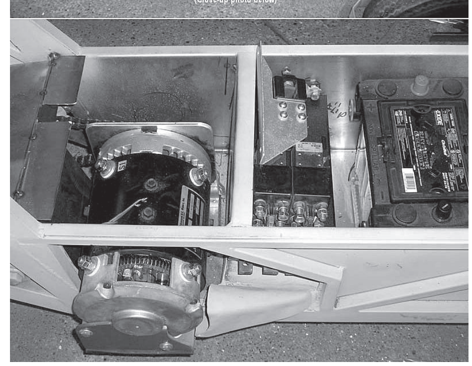
Therefore, I had to hold back on the throttle. Even so, the ride was still great fun. After a few trips up and down some hills, with time to let the controller cool off in between, I brought the bike back in and put the controller's cover on.

On the second test ride, it became clear that the fan wasn't providing enough cooling for the controller. The base of the controller under the MOSFET's heatsink was extremely hot, and the plastic under it was slightly discolored. The solution was simple, though, involving a Dremel tool and a larger fan. I cut out an opening beside the heatsink, and plugged up the original air outlet, forcing all the air to go through the heatsink. Voilà, problem solved. I would have done this in the first place, but the MOSFETs dissipated more power than I calculated they would.

The only other problem I have had with this bike is it getting stuck at part throttle due to the toothed belt on the throttle adapter slipping. I later replaced it with a Magura twist grip throttle.

This bike cost about $1600 to build, which is about twice what a commercial E-Bike would cost. The far greater range and power more than make up for the cost, though. The bike's range is about 25km at 25km/h, and it has a measured top speed of 43km/h.

All in all, this project was a great learning experience, and produced a very satisfactory vehicle. Its construction taught me a great deal about motor controller design, metalworking, and mechanical design. I encourage anyone who has an interest in Electric Vehicles to build one, be it a small scooter or a full size car or truck.



Note that this controller design is used in Jan Engstrom's Trike.

By Trevor Blackwell, Copyright 2004

[Editor note: in the Mar/Apr and May/Jun issues of CE we featured Trevor's two-wheel scooter. Here is his latest EV development.]

Some time ago I built a self-balancing two-wheeled scooter. Since then I realized that two wheels are redundant, and only a single wheel is needed to make a ridable vehicle. A vehicle with a single wheel is much smaller and lighter. It's easily carried with one hand when going up stairs or on public transportation.

In theory, operation is very simple: just sit on it and lean to change speed and twist to change direction. In practice, it takes a while to learn to ride it competently.

The Eunicycle balances itself using a simple feedback loop between a solid-state gyroscope and the wheel motor. When it detects itself tilting forward, it runs the wheel forward to keep it under the center of gravity. When it detects itself tilting backwards it runs the wheel backwards. It does this so rapidly, about 200 updates per second, that it feels perfectly smooth.

Riding

Speed is controlled just like for a 2-wheeled balancing scooter, by leaning. Lean forward to accelerate and lean back to decelerate or go backwards. Swiveling your hips and arms controls the side-to-side balance and steering. It's helpful to keep your arms partly outstretched, as I'm doing in the photo.

Seat height is set so I can comfortably touch the ground with both feet while sitting on the seat. At a stop, I can just put my feet down. When starting, I put one foot on a foot peg and steady myself with the other while accelerating.

What I said about safety for the two-wheel scooter applies, but there is a major difference. While the 2-wheeled scooter is easy to ride (I've let maybe 100 people ride it with few problems) the Eunicycle takes a good deal of practice. You don't want to be learning how to control such a vehicle at the same time as debugging it, so you really need to learn to ride a regular unicycle first. I got a "United 24-inch Trainer for Extra Large Adults" from Unicycle.com and spent a couple months learning to ride it before I built the Eunicycle.

Components

All together the components, in single unit retail quantities, cost about $1100. They are:

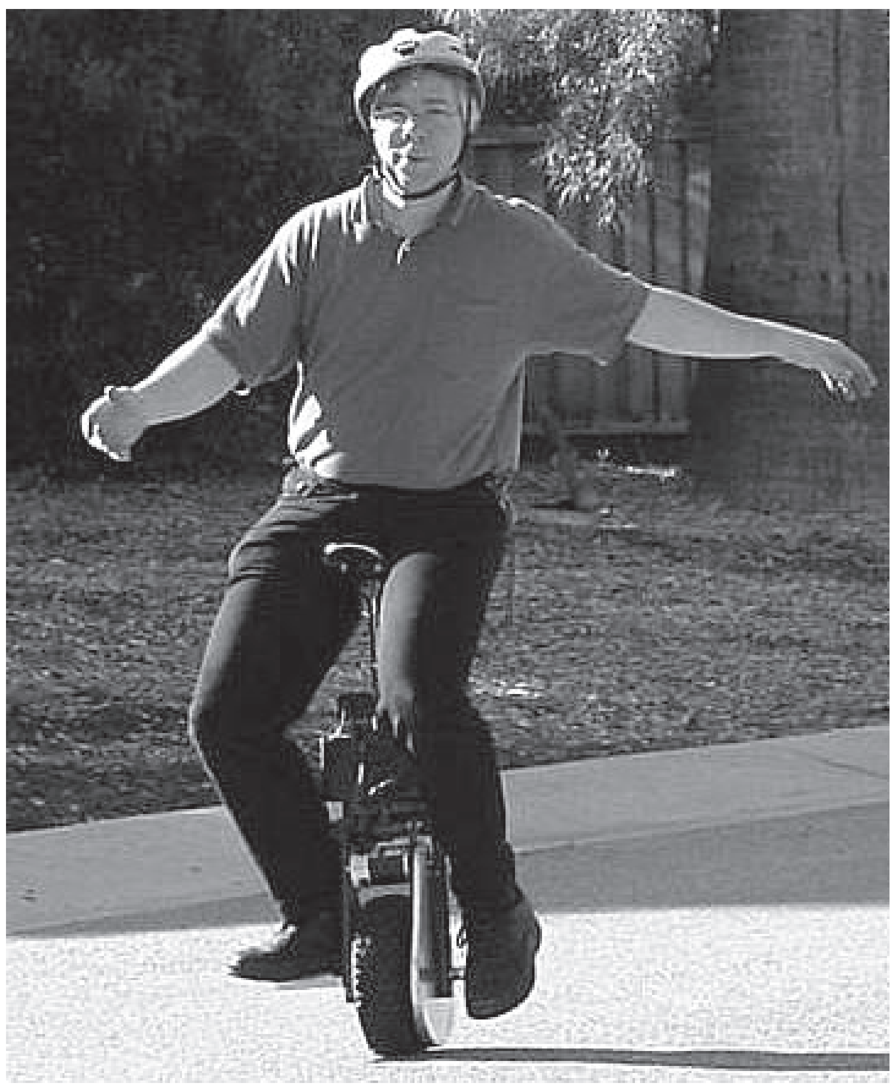
A microcontroller board from BDMicro featuring the Atmel AVR Mega 128	$125.
A gyroscope and accelerometer by Rotomotion	$149.
The OSMC motor controller by Robot Power	$199.
40 NIMH cells, made into nice packs by Robot Marketplace	$218.
A 12 inch diameter tire	$ 13.
A hub with integral bearing	$ 27.
A 72-tooth sprocket for the above	$ 20.
A Magmotor S28-150	$299.
A 10-tooth pinion	$ 10.
Some ANSI #35 chain	$ 20.
Some 1" diameter tubing, TIG-welded together	$ 40
Some spacer bushings to center the wheel.	
A chain guard, made from cut, bent, and welded aluminum sheet.	
A combination dead man's switch and key	$ 12.
A unicycle seat	$ 24.

Downloads

You can download the complete software here (http://tlb.org/unicycle-0.1a.tgz). The mechanical fabrication drawings are available in Postscript (http://tlb.org/unicycle-drawings.ps) and as an eDrawing (http://tlb.org/unicycle4.edrw). I'll try to post schematics and some interior pictures soon.

Links

The Einrad-Fahrzeug (http://fhznet.fh-bielefeld.de/fb2/labor-le/le3einrad.html)



Firefly Energy's New Batteries

Firefly Energy, a company formed after its technology, technical founder and initial seed funds were spun out of Caterpillar, Inc., is the developer of a next-generation lead acid battery technology.

According to Firefly Energy, the battery technology is capable of delivering a combination of high performance, low weight and low cost, while overcoming the corrosive drawbacks of lead acid chemistry. When compared to the market's current lead acid battery products, Firefly Energy said its technology delivers four times greater power density; less than one-fourth the weight; double the life expectancy; a seven times faster recharge rate; and lead acid equivalent manufacturing costs.

Additionally, Firefly Energy noted that the product technology can be manufactured as well as recycled within the existing lead acid battery industry's infrastructure.

Bollore, Matra to Unveil New Prototype Electric Vehicle

Bollore and Matra Automobile Engineering in the U.K. plan to unveil the VBE1, a new electric vehicle prototype designed for urban applications, at the 2005 Geneva Motor Show next March in Geneva, Switzerland.

The companies said the VBE1, which is equipped with lithium metal-polymer batteries developed by Batscap, is capable of reaching speeds of up to 80 miles per hour and traveling approximately 200 to 300 kilometers per charge.

The companies plan to test the VBE1 later this year, with hopes to eventually secure development contracts with vehicle manufacturers.

NEV Use Among Residents of CA Locality Increasing

The Los Angeles Times recently reported on the growing use of neighborhood electric vehicle (NEV) by residents on Balboa Island for local errands around town.

According to the paper, popular models include DaimlerChrysler's global electric motorcar (GEM) and Ford Motor Company's Think electric vehicle.

"With the price of gas, people are staying close to home, and this makes staying closer to home more fun," said Balboa Island resident and Think electric vehicle owner Bob McKenzie.

AC PROPULSION PROGRESS ON EV SCION

The Hankster is under way.

This Fall, Tom Hanks of movieland and Tom Gage of ACP met to receive some Toyota Scions. These vehicles will be the shell/ conversion for Lithium battery EVs. So, progress is being made. More information from the ACP website, under "**FAQ - tzero and other AC Propulsion EVs**":

Does AC Propulsion plan to build any other electric vehicles?
AC Propulsion studying a plan to manufacture safety-certified electric vehicle conversions and sell them to retail and fleet customers. The conversions will be based on the Scion xA and xB, the new sport compact vehicles built by Toyota. A base model, and a premium model with a larger battery will be developed. The base model will outperform the Toyota RAV4 EV and is expected to sell for about the same price. First production is planned in 2005.

Tom Hanks with the soon-to-be EV Scion

Why the Scion?
Not everyone likes the looks of the Scions. One critic says "yes, they have the look of the future, but right now they're ugly". But, from the perspective of our plan to build EV conversions and make money doing so, we have not found a better vehicle to start with. The gasoline Scion costs less than $15,000 well-equipped and weighs less than 2400 pounds. The xB is huge inside. The xA has a sporty, aggressive stance. The xA and xB are built on the same platform so development costs are reduced. The xB in particular appeals to fleets. They are Toyotas but they don't look like it. To get the best range and performance in an EV with the broadest appeal and the lowest price, the Scion has the looks of a winner.

Tom owns and drives a Toyota RAV4 EV

Tom Gage, President of AC Propulsion, picking up a Scion xB for EV conversion

NOMINATIONS FOR THE 2005 TERM EAA BOARD OF DIRECTORS

By Bill Carroll, EAA Elections

Elections... something that is with us always.

Each year it seems that there is an election held for our National Board. This is easily explained. Our National Board is composed such that there is always be a cadre of people who know what is in the works for our organization. Each seat on the Board is for a three-year term and the terms are staggered, meaning that at least one but no more than four seats are up for election at any one time.

This year there are four seats open – two seats for renewal (Scott Leavitt and Gabrielle Adelman), and two additional seats to fill. Let me point out something that has bothered me in the past, "it seems that Board Members were elected because they have much experience in electric cars". There is no requirement that one must own an electric car to serve on the Board. What IS needed is the willingness to serve. There are many roles to be filled by Board Members, and delegates alike.

We also have need for delegates from each chapter. At the present time we have two delegates who attend our meetings regularly; we need more. Being a delegate will ensure that your Chapter will have input into what is happening nationally.

My request is for candidates' statements to be received by November 10, 2004, at the latest, so that they may be included in the next issue of CE. This way our membership will know a bit about people who are willing to serve on the Board.

Candidates can send their candidate statements using email to the Election Committee Chairman:

Bill Carroll
<billcarroll@eaaev.org>
or to Membership Chairman:
Will Beckett
<membership@eaaev.org>

or snail-mail to:
W.D. Carroll
160 Ramona Ave.
So. San Francisco, CA 94080.

NOMINATIONS FOR THE EAA KEITH CROCK AND FELLOW AWARDS

The EAA would like to receive nominations for our EAA Fellow Award and Keith Crock Awards.

The Fellow Award is made to individuals for outstanding activities in areas relating to support of the EAA, advancing the cause of electric vehicles, or other activities of benefit to the EV industry.

The Keith Crock Award can be given to an individual, a group, a company, or their organization. This award is given for technical excellence and can be in the form of a vehicle, component, a drive system, supporting infrastructure, etc.

We ask that anyone wishing to make a nomination, submit in any form they chose, all pertinent information such as; nominees name, email, phone, address, award (Fellow or Keith Crock), and as detailed a description of EV activities and accomplishments of the nominee(s).

Please provide the candidate's photo (electronic jpg file or hard copy) if possible. Submissions will also be considered for profile in CE, and will be an excellent way for us to have these profiles in our historical records. Addresses and phone numbers will not be given out, without the nominee's permission.

Please send your nomination by Dec.30, 2004 to:
Terry Wilson
20157 Las Ondas Way
Cupertino,Ca.95014-3132
eaaregistrar@yahoo.com

EAA VIRTUAL TOWN HALL MEETING

The Board would like to initiate a regular telephone conference call with Chapter Officers, to facilitate communications within the organization.

We plan to start in January 2005. Details will be forthcoming from Jerry Asher <evisionA2Z@usa.net>. Those who will particiate in this virtual town hall meeting will be contacted by telephone or email for specifics about the planned time, date and telephone number.

Board of Directors 2004

Chairman
Ron Freund
chairman@eaaev.org

Membership Chapter Relations West
Will Beckett
membership@eaaev.org

Secretary
Scott Leavitt
secretary@eaaev.org

Treasurer
Gabrielle Adelman
treasurer@eaaev.org

Chapter Relations East
Jerry Asher
ChapterRelationsEast@eaaev.org

Elections Board Calendar
Bill Carroll
electionadmin@eaaev.org

Education Program Manager
Kim Rogers
education@eaaev.org

East Coast Coordinator
Karen Jones

Nick Carter

Delegates:
Tom Dowling - *EV Charging*
charging@eaaev.org

Charlie Garlow - *Junior Solar Sprints*
juniorsolar@eaaev.org

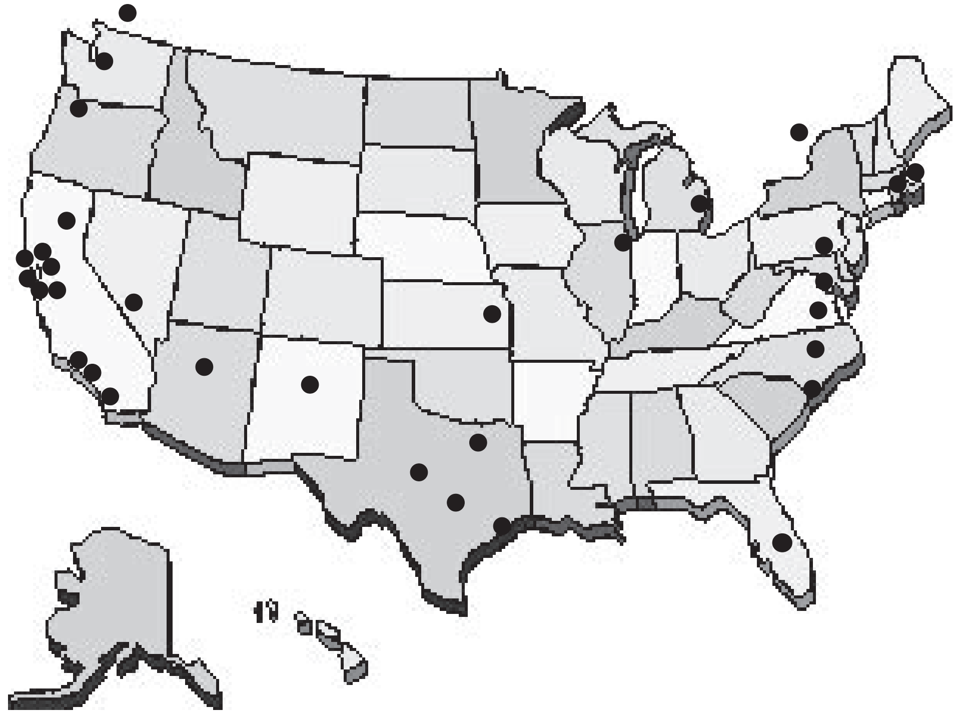
Ed Thorpe - *CE Publications*
ceeditor@eaaev.org

Terry Wilson - *Historian, Awards*
historian@eaaev.org

EAA Board contact:
board@eaaev.org 1-510-864-0662

Notice: IRS requires us to ask for a full disclosure by the donor for donations of $1000 or more. This should include Full Name, Complete Address, Phone Number, and Social Security or Tax ID Number.

ELECTRIC AUTO ASSOCIATION CHAPTERS



CANADA

VANCOUVER EVA (VEVA)
Web Site: http://www.veva.bc.ca
Contact: Haakon MacCallum,1-604-258-9005, info@veva.bc.ca
Mailings: P.O. Box 3456, 349 W. Georgia St., Vancouver, BC V6B3Y4, Canada
Meetings: 3rd Wed./month, 7:30 pm
Location: BCIT Electrical Bldg SE1 Cafeteria - see map on website

EV COUNCIL OF OTTAWA (EVCO)
Web Site: http://www.evco.ca
Contact: Alan Poulsen, 1-613-271-0940, info@evco.ca
Mailings: P.O. Box 4044, Ottawa, ON K1S 5B1 Canada
Meetings: Last Mon./month, 7:30 pm
Location: The Canada Science & Technology Museum, 1867 St.Laurent, Ottawa

UNITED STATES

ARIZONA

PHOENIX EAA (PEAA)
Web Site: http://www.phoenixeaa.com/
Contact: Sam DiMarco, 1-480-948-0719, voltek_2000@yahoo.com
Mailing: PO Box 6465, Scottsdale, AZ 85258-6465, USA
Meetings: 4th Sat./month, 9:00 am
Location: Varies, see Web Site for details.

CALIFORNIA

CHICO EAA (CEAA)
Web Site: http://www.geocities.com/chicoeaa/
Contact: Chuck Alldrin, 1-530-899-1835, calldrin@sunset.net
Mailing: 39 Lakewood Way, Chico, CA 95926-1555, USA
Meetings: 2th Sat./month, 10:00 am.
Location: 1350 East 9th St, Chico, CA

EAST (SF) BAY EAA (EBEAA)
Web Site: http://www.ebeaa.org/
Contact: Ed Thorpe, 1-510-864-0662, eaa-contact@excite.com
Mailing: 2 Smith Ct., Alameda, CA 94502-7786, USA
Meetings: 4th Sat./month, 10:00 am.
Location: 1515 Santa Clara Ave, Alameda, CA

LOS ANGELES EAA (LAEAA)
Contact: Louis Weiss, 1-323-935-2690, warbucks@attbi.com
Mailing: 1811 Hi Point St., Los Angeles, CA 90035-4621, USA
Meetings: 1st Sat./month, 10:00 am
Location: 1200 E California Blvd, Pasadena, CA

NORTH BAY EAA (NBEAA)
Web Site: http://www.nbeaa.org
Contact: Nick Carter, 1-707-573-9361, nick@npcimaging.com
Mailing: 2228 Magowan Drive, Santa Rosa, CA 95405
Meetings: 2nd Sat./month, 10:00 am
Location: See web site or contact for meeting location.

SAN DIEGO EVA (SDEVA)
Web Site: http://home.att.net/~NCSDCA/EVAoSD/
Contact: Chris Jones, 1-619-913-6030, NCSDCA@WorldNet.ATT.net
Mailing: 315 South Coast Highway 101, Encinitas, CA 92024-3543, USA
Meetings: 4th Tues./month, 7:00 pm
Location: 2080 Pan American Plaza, Balboa Park, San Diego

SAN FRANCISCO EAA (SFEAA)
Web Site: http://www.sfeaa.org/
Contact: Sherry Boschert, 1-415-681-7716, shaalub@yahoo.com
Mailing: 1484 16th Ave., San Francisco, CA 94122-3510, USA
Meetings: 1st Sat./month, 11:00 am
Location: Varies, see web site for details.

SF PENINSULA EAA (SFPEAA)
Web Site: http://geocities.com/sfpeaa/
Contact: Bill Carroll, 1-650-589-2491, billcarroll@eaaev.org
Mailing: 160 Ramona Ave., San Francisco, CA 94114-2736, USA
Meetings: 1st Sat./month, 10:00 am
Location: 601 Grand Ave, South SF, CA

SAN JOSE EAA (SJEAA)
Web Site: http://www.geocities.com/sjeaa/
Contact: Terry Wilson, 1-408-446-9357 dongillis@yahoo.com
Mailing: 20157 Las Ondas Way, Cupertino, CA 95014-3132, USA
Meetings: 2nd Sat./month, 10:00 am
Location: 2350 Cunningham Ave., San Jose, CA

SILICON VALLEY EAA (SVEAA)
Web Site: http://eaasv.org/
Contact: Will Beckett, 1-650-494-6922, will@becketts.ws
Mailing: 4189 Baker Ave., Palo Alto, CA 94306-3908, USA
Meetings: 3rd Sat./month, 10:00 am
Location: 3000 Hanover St., Palo Alto, CA

VENTURA COUNTY EAA (VCEAA)
Web Site: http://www.geocities.com/vceaa/
Contact: Bruce Trucker, 805-495-1026, tuckerb2@adelphia.net
Mailing: 283 Bethany Court, Thousand Oaks, CA 91360-2013 ,USA
Meetings: Call or email for location/meetings.

ELECTRIC AUTO ASSOCIATION CHAPTERS

FLORIDA

FLORIDA EAA (FLEAA)
Web Site: http://www.floridaeaa.org
Contact: Shawn Waggoner, shawn@suncoast.com
Meetings: Varies, see website

KANSAS / MISSOURI

MID AMERICA EAA (MAEAA)
Web Site: http://maeaa.org/
Contact: Mike Chancey, 1-816-822-8079, eaa@maeaa.org
Mailing: 1700 E. 80th St., Kansas City, MO 64131-2361, USA
Meetings: 2nd Sat./month, 1:30 pm
Location: See web site for details.

ILLINOIS

FOX VALLEY EAA (FVEAA)
Web Site: http://www.fveaa.org/
Contact: Bill Shafer, 1-708-771-5202, assessorbill@cs.com
Mailing: 1522 Clinton Place River Forest, IL 60302-1208, USA
Meetings: 3rd Fri./month 7:30 pm
Location: 2000 Fifth Ave., River Grove, IL

MASSACHUSETTS

NEW ENGLAND EAA (NEEAA)
Web Site: http:/neeaa.org/
Contact: Tony Ascrizzi, 1-508-799-5977, tonyascrizzi@juno.com
Mailing: 34 Paine Street, Worcester, MA 01605-3315, USA
Meetings: 2nd Sat./month, 2:00 pm
Location: Call or email for meeting location.

PIONEER VALLEY EAA (PVEAA)
Web Site: http://geocities.com/pveaa/
Contact: Karen Jones, 1-413-367-9585, pveaa@hotmail.com
Mailing: P.O. Box 153, Amherst, MA 01004-0153 USA
Meetings: 3rd Sat./month, 2:00 pm
Location: 43 Amity Street, Amhurst, MA.

MICHIGAN

DMC-EAA DETROIT MOTORCITY CHAPTER (DMCEAA)
Web Site: http://geocities.com/detroit_eaa/
Contact: Richard Sands, 1-734-281-4087, rsands01@comcast.net
Mailing: 13162 Fordline St, Southgate, MI 48195-2435, USA
Meetings: Call or email for location/meetings.

NEVADA

LAS VEGAS EVA (LVEAA)
Web Site: http://www.lveva.org/
Contact: William Kuehl, 1-702-645-2132, bill2k2000@yahoo.com
Mailing: 4504 W. Alexander Rd., N. Las Vegas, NV 89115-2489, USA
Meetings: 2nd Sat./month, 10:00 am
Location: 1401 E. Flamingo Rd, Las Vegas, NV

NEW MEXICO

ALBUQUERQUE EAA (AWAA)
Web Site: http://abqev.org/
Contact: Tom Stockebrand, 1-505-856-1412, info@abqev.org
Mailing: 1013 Tramway Ln NE, Albuquerque, NM 87122-1316, USA
Meetings: 1st Tues./month, 7:00 pm
Location: 6810 Menaul NE, Albuquerque, NM

NORTH CAROLINA

COASTAL CAROLINAS (EAACC)
Contact: Jayne Howard, 1-910-457-4383, EAAofCC@aol.com
Mailing: 4805 E. Southport Supply Rd., Hwy 211, Southport, NC 28461-8741, USA
Meetings: Varies, call for details.
Location: 4805 E. Southport Supply Rd., Hwy 211, Southport, NC

TRIANGLE EAA (TEAA)
Web Site: http://www.rtpnet.org/teaa/
Contact: Ken Dulaney, 1-919-461-1241, teaa@rtpnet.org
Mailing: 202 Whitehall Way, Cary, NC 27511-4825, USA
Meetings: 3rd Tues./month, 5:30 pm
Location: Varies, call for details.

OREGON

OREGON EVA (OEVA)
Web Site: http://www.oeva.org/
Contact: Ralph Merwin, prizmev@yahoo.com
Mailing: 2905 NE 29th Ave., Portland, OR 97212-3558, USA
Meetings: 2nd Thur./month, 7:30 pm
Location: SW Salmon & 1st St, Portland, OR

PENNSYLVANIA

EASTERN EV CLUB (EEVC)
Web Site: http://members.aol.com/easternev/
Contact: Peter Cleaveland, 1-610-828-7630, easternev@aol.com
Mailing: P.O. Box 717, Valley Forge, PA, 19482-0717, USA
Meetings: 2nd Wed./month, 7:00 pm
Location: 201 E Germantown Pk, Plymouth, PA

TEXAS

AUSTIN AREA EAA (AAEAA)
Web Site: http://www.austinev.org/
Contact: Aaron Choate, 1-512-453-2890, info@austinev.org
Mailing: PO Box 49153, Austin, TX 78765, USA
Meetings: Call or email for location/meetings.

HOUSTON EAA (HEAA)
Web Site: http://www.heaa.org/
Contact: Dale Brooks, 1-713-729-8668, brooksdale@usa.net
Mailing: 8541 Hatton St., Houston, TX 77025-3807, USA
Meetings: 3rd Thurs./month, 6:30 pm
Location: 3015 Richmond Ave., Houston, TX

NORTH TEXAS EAA (NTEAA)
Web Site: http://www.geocities.com/nteaa/
Contact: Paul Schaffer, 1-972-437-1584, pshf@hotmail.com
Mailing: 430 Ridge Crest, Richardson, TX 75080-2532, USA
Meetings: Varies, call/email for details.

VIRGINIA

CENTRAL VIRGINIA EAA (CVEAA)
Contact: Ernest Moore, 1-804-271-6411, ernie_moore@yahoo.com
Mailing: 4600 Melody Ct., Richmond, VA 23234-3602, USA
Meetings: 3rd Wed./month, Call for details.
Location: Westwood Ave., Richmond, VA.

WASHINGTON

SEATTLE EVA (SEVA)
Web Site: http://www.seattleeva.org/
Contact: Steven Lough, 1-206-524-1351, stevenslough@comcast.net
Mailing: 6021 32nd Ave. NE, Seattle, WA 98115-7230, USA
Meetings: 2nd Tues./month, 7:00 pm
Location: See website, call for details.

WASHINGTON D.C.

EVA OF WASHINGTON DC (EVA/DC)
Web Site: http://www.evadc.org/
Contact: David Goldstein, 1-301-869-4954, goldie.ev1@juno.com
Mailing: 9140 Centerway Rd., Gaithersburg, MD 20879-1882, USA
Meetings: 2nd or 3rd Tues./month, 7:00 pm
Location: Building 31-C, 6th, Bethesda, MD.

Listing updated, verified and current as of this issue. Check main web page for any changes in current listing. The Electric Auto Association is a 501 (c)(3) nonprofit organization.

Check out the ScubaDoo, a cute little underwater EV. It is powered by a 12V 72Ah gel cell into a 12V 40A PM motor. Here's manufacturer's description of this new type of EV.

Scubadooing means you don't need to wear a mask or a mouthpiece as in diving, and the air tank and diving weights are on the ScubaDoo, not you!

You are seated on your ScubaDoo, with your head and shoulders within a clear dome, your air constantly replenished from the Scuba tank, enabling you to breathe normally!

Manoeuvrable? You bet! At a rate of 2.5 knots you're able to ride amongst the spectacular underwater world, or remain stationary while you feed the fish.

Wear your spectacles or contact lenses in the ScubaDoo—No problem!

There's no need to be a strong swimmer, in fact the ScubaDoo is even used by people with minor disabilities.

Your Dive Instructor will show you the safety techniques of the ScubaDoo, and you'll be off enjoying yourself in just a few minutes, while those doing a resort scuba dive are still doing their class.

http://scuba-doo.com.au/

Info:

Scubadooing means you don't need to wear a mouthpiece as in diving, and the air tank and diving weights are attached to the Scuba-Doo and not you!

You are seated on the Scuba-Doo, with your head and shoulders within a clear dome, your air constantly replenished by the Scuba-Doo Tank, enabling you to breathe normally!

Manouverable? You bet! At a rate of 2.5 knots you are able to ride amongst the spectacular underwater world, or remain stationary and feed the fish.

Wear your spectacles or contact lenses in the Scuba-Doo—no problem. There's no need to be a strong swimmer, in fact the Scuba-Doo is even used by people with minor disabilities.

- No mouthpiece to fumble with when underwater
- No need to fit a mask when using the Scuba-Doo
- No requirement to fit or use a weight belt
- No lengthy courses, get underwater sooner and enjoy the wonderful experience
- No bulky tank to hinder your movement whilst underwater
- Get underwater quicker

Your dive instructor will explain and demonstrate all of the safety techniques prior to you entering the water.

Specifications:

Battery approx: 1.5 hours

Air Tank: The duration of the air tank depends onthe amount of times the buoyancy tanks are inflated. Normal use under instructors supervison 88 c.f. tank approx 1 hour

Dimensions:
Imperial Metric
Height 4' 5" 1.35 meters
Width 2' 6" (with dive lights) 0.71 meters
Length 3' 0.91 meters

Weights: Imperial Metric
Scubadoo 56 lbs 25.5 kgs
Battery 38 lbs 17.3 kgs

Maximum Depth:
The intended use of this vehicle is for shallow water operation.The vehicle should never exceedits buoy safety length.

Maximum Speed: 2.5 knots

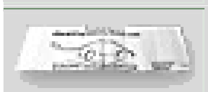
Electric Motor: Permanent Magnet 12 volt DC, 40 amps, 35 lbs thrust

Battery: 12 volt sealed gel cell 72 amp-hour

Whinching: The vehicle is equipped with a hook to lift and lower it from a vessel by davit

EAA MERCHANDISE

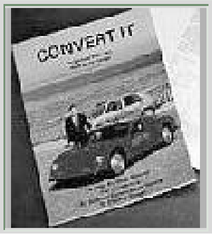
-- General Items --

	*License Plate Holder, black plastic frame, white lettering on visible green.*	LICPH1	$10.00	
License Plate	*Motorcycle size, only in metal & black or chrome. (Special order, need additional 6 weeks.)*	Black: LICPH2-B Chrome: LICPH2-C	$14.00	
	*Embroidered Sew-On Patch, white. (Special order, allow an additional 3 weeks.)*	PATCH1	$ 9.00	
	*Embroidered Sew-On Patch, green. (Special order, allow an additional 3 weeks.)*	PATCH2	$ 9.00	
	*Embroidered Bucket Hat, comes in: small/medium & large/xlarge.*	S/M: DCP01-SM L/XL: DCP01-LXL	$25.00	
	*Ceramic Coffee Mug.*	MUG003	$ 5.50	
	*Insulated Car Coffee Mug.*	MUG02	$ 6.50	
	*Embroidered Polo Shirt (Forest or navy S,M,L,XL,XXL), 10 weeks for all colors other than Forest.*	SHIRT01-F-S SHIRT01-F-M SHIRT01-F-L SHIRT01-F-XL SHIRT01-F-XXL Same for SHIRT01-N-…	$40.00	
	*EAA Car Window Shade.*	SS001	$ 8.00	
	*EAA Bumper Sticker #1 (10.5"x3.75").*	BS800	$ 2.00	
	*EAA Bumper Sticker #2 "The Switch is on"(15"x3.75")*	BS002	$ 2.00	

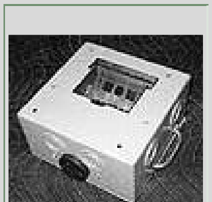
-- EV Buyers Guides --

	**Electrifying Times Preview 2004 *Electrifying Times Preview 2000 *1997 EV Buyers Guide *1996 EV Buyers Guide *1995 EV Buyers Guide*	ET2002 ET1999 BG1997 BG1996 BG1995	$ 5.95	

-- Literature --

	*Convert-It EV conversion Book*	CONV01	$24.95	
	*KTA Electric Vehicle Kits & Component Parts Catalog*	CATAL1	$5.00	
	Window Literature Holder (light plastic)	WL002	$15.00	
Indicate Month/Year and/or Vol #, back 20 yrs.	*Back issues of CE (Current EVents) magazine*	CE001	$ 3.00	

-- Special --

	*AVCON to 14-50 adapter kit - sheet metal box, 14-50 outlet (2 hots and a ground, no neutral), for 220 VAC chargers, no 120 VAC (6weeks)*	ADAPT1	$255.00	
(fill out complete membership form on flip side of page)	***Electric Auto Association Membership ($10 rebates to local chapter.)***	***6 /year of Current EVents, member voting rights***	$39.00	

Shipping: USA 10%, Canada 15%, All Others 20% of subtotal
Handling $2.00 Send check (USA dollars) to:

EAA Merchandise, 5820 Herma St, San Jose, CA 95123 USA

Electric Auto Association (EAA) Membership Application Form

Copy and fill out this form, attach a check or money order or use PayPal in US funds only for $39 ($42 Canada) ($45 International) payable to **Electric Auto Association**. You can fold this form as indicated and mail it with your payment enclosed. Use tape to seal the form before you mail it. Or send information in this form and pay through PayPal using http://eaaev.org/membership.htm.

New Member: ❑ Renewal: ❑ Country (if non-USA):__________________________ Date: ____________

Name: ____ *email: ______________________

Mailing Street Address: ______________________________ Home phone#: __________________

Mailing City, State & ZIP: _____________________________ *Work phone #: _________________

*Do you ❑ own or ❑ lease an Electric Vehicle? ❑ Production ❑ Conversion ❑ Bicycle ❑ Other:__________ ❑ No

I support the ________________________________ EAA Chapter, or please select an EAA Chapter closest to me. ❑

(*optional) All information in this application is for the exclusive use of the EAA and not be sold or given to any other organization.

(fold back ward, this will protect your personal information, placing it on the inside)

Please Identify your primary areas of interest relating to the EAA (check as many as you wish):

❑ Hobby/Builder ❑ Professional (income) ❑ Competition (Rallies, Races, Records) ❑ Owner/Driver

❑ Environmental/Gov. Regs. ❑ Social (Rallies, Shows, Dinners) ❑ New Technology & Research

❑ Promotion & Public Awareness of EVs ❑ Student or General Interest ❑ Electrathon/Bicycle/other

The Electric Auto Association www.eaaev.org

Providing free Electric Vehicle information to the public since 1967'

The Electric Auto Association is a non-profit, 501(c)(3) for the promotion of electric vehicles. Membership includes the informative complementary EAA publication, **Current EVents**. Donations are tax deductible. All information and statistics in this application are for the exclusive use of the EAA and is not sold or given to any other organization or company.

From your membership dues, a percentage goes to the EAA Chapter you support for public Electric Vehicle promotion EVents like rallies, shows and EV rides.

(fold the bottom half under. This will now be the front of the letter. Be sure to seal it with tape)

Return address

____

____

____

membership@eaaev.org

1st Class Postage Here

Electric Auto Association
Membership Renewals
4189 Baker Ave.
Palo Alto, CA 94306-3908 USA

EV CONFERENCE AND EAA CHAPTER EVENTS CALENDAR

September 21-24, 2004
EUROPEAN LEAD BATTERY CONFERENCE
Berlin, Germany
Ninth International conference focused on battery use, technology and manufacturing of lead-acid batteries.
Web Site: http://www.ldaint.org/9elbc

September 25, 2004
NEDRA NATIONALS
Woodburn, Oregon, USA
Premiere electric drag race event at the end of summer.
Web Site: http://http://www.nedra.com

October 9, 2004
SVEAA ELECTRIC CAR RALLY
Palo Alto, California, USA
32nd Annual Silicon Valley Chapter EV distance rally and display/ride event.
Web Site: http://eaasv.org

October 16, 2004
SUSTAINABLE TRANSPORTATION RALLY AND FESTIVAL
Amherst, Massachusetts, USA
Pioneer Valley EAA Chapter participates with other alternative fuel vehicles.
Web Site: http://geocities.com/pveaa

November 1 - 5, 2004
The 2004 Fuel Cell Seminar
San Antonio, Texas, USA
The Fuel Cell Seminar offers technical papers, exhibits and coverage of the latest technical advances.
E-mail: fuelcell@courtesyassoc.com
Web Site: http://www.fuelcellseminar.com

November 2 - 7, 2004
38th Tokyo Motor Show: Commercial & Barrier-Free Vehicles
Makuhari, Chiba
Web Site: http://www.tokyo-motorshow.com/eng

November 4 - 9, 2004
International Hydrogen + Fuel Cells Group Exhibit, Shanghai
Pudong, China
International Industry Fair
The first Chinese Group Exhibit on Hydrogen + Fuel Cells will take place annually at the Shanghai International Industry Fair.
E-mail: arno@fair-pr.com
Web Site: http://www.fair-pr.com

November 20 - 21, 2004
GEORGIA EV RALLY
Jefferson, Georgia, USA
Student teams will be competing in the 8th Georgia Electric Vehicle Rally.
Web Site: http://www.eveducation.org/

December 2, 2004
2020: California's Transportation Energy Future Conference
Los Angeles, California, USA
This forum will discuss California's actions to become the first state to establish a petroleum reduction goal and plan. This one-day conference will present the need, technologies, methods, and modes for reducing California petroleum consumption and increasing the use of non-petroleum fuels by the year 2020, as recommended in a joint report by the California Air Resources Board and California Energy Commission. CALSTART will also present its prestigious Blue Sky Awards for 2004 at the luncheon.
E-mail: mpeak@calstart.org or malcaraz@calstart.org
Web Site: http://www.calstart.org

January 15 - 21, 2005
FC Expo 2005
Tokyo, Japan
The first international tradeshow specialized in exhibiting fuel cells and hydrogen related technologies/products.
E-mail: fc@reedexpo.co.jp
Web Site: http://www.fcexpo.jp/english

April 2 - 6, 2005
EVS 21: The 21st Worldwide Battery Hybrid and Fuel Cell Electronic
Monte Carlo, Monaco
Vehicle Symposium & Exhibition
Developers and investors will explore and present viable solutions of advanced vehicle technology towards their vision for sustainable mobility.
E-mail: info@evs21.org
Web Site: http://www.evs21.org

April 11 - 15, 2005
International Hydrogen + Fuel Cells Group Exhibit, Hannover Fair
Hannover, Germany
The world's biggest commercial exhibition on Hydrogen + Fuel Cells, with 24 countries representing their latest H2/FC developments and products. .
E-mail: arno@fair-pr.com
Web Site: http://www.fair-pr.com

Note: EAA Chapters.
Any major event information should be sent to cenews@eaaev.org for inclusion in the newsletter, at least 2-3 months ahead of event date. If you have recurring annual events, please provide New Year schedule at the start of the year. We want to maintain focus on EAA-specific events.

EAA **Chapter** Event = (flag)
EV related **Event** = (bus)
EV related **Conference** = (plane)

ELECTRIC AUTO ASSOCIATION
2 Smith Ct, Alameda, CA 94502-7786

NON-PROFIT ORG.
U.S. POSTAGE PAID
HAYWARD, CA
PERMIT #546