"SELECTING A VEHICLE FOR CONVERSION"

by Bob Batson

Electric Vehicles of America, Inc.

www.EVAmerica.com

INTRODUCTION

The decision to convert my first EV in 1987 was very simple. It was a 1973 VW which was in the process of being converted to electric. I helped its owner complete the conversion, and then I purchased the vehicle from him. After I purchased the vehicle, I invested $1500-$2000 into the vehicle for new brakes, tires, PMC controller, and paint job. My purpose for the VW was to demonstrate the feasibility of EVs and to learn from the experience.

Later, I found the VW limiting because of the space available for batteries and the location of batteries within the passenger compartment. Consequently, after a couple of years of driving the VW Beetle, I was itching to try another vehicle And this time I was going to select the vehicle based on an engineering evaluation.

After proceeding through the selection process, I determined that "selecting a vehicle" to convert to an Electric Vehicle (EV) can be as simple as 1 - 2 - 3 :

1. Define your requirements for the vehicle.

2. Evaluate the vehicles classes that meet your requirements.

3. Select one or two specific vehicles models.

STEP 1. DEFINE THE PURPOSE OF THE VEHICLE

This is the major decision. Ask yourself the following questions:

Why do you want an EV?
Where will you drive it?
Who else will drive it?
How many miles do you require on a daily basis?
How often will you drive the vehicle?
With or without passengers?
Will your employer allow me to charge at work?
How much do I want to spend?
How much time do I have for the conversion?

These are important questions that must be answered.

My purpose for my second vehicle was finally selected: To demonstrate that EVs can be larger vehicles which serve a useful function. And my criteria became:

A vehicle designed for the extra battery weight. Battery weight represents fuel weight; the more fuel you carry, the greater your range.

A vehicle that allowed all batteries to be located outside the passenger compartment. This makes it easier to restrain the batteries in designing for an accident. I felt it was a safer design.

A vehicle that allowed components to be easily replaced for testing new EV components. I did not want to bury components in inaccessible places.

A small passenger compartment to limit the heating requirements in the New England winter.

STEP 2. EVALUATE THE VEHICLES MANUFACTURED

Once you start to evaluate the different vehicles you find there are three classes:

1. Sports cars,
such as the Honda CRX, Pontiac Fiero, Toyota MR2, Porsche 914, Fiat X-19, Nissan Pulsar, MGB or MG Midget. Sports cars have limited space and minimal payload capacity.

2. Passenger cars and vans,
such as the Ford Escort, VW Rabbit, VW Beetle, Saturn, Honda Civic, Geo Metro, VW Vanagan, and Dodge Caravan. Vans are considered herein as a passenger car because they require the batteries inside the passenger compartment. The payload capacity within this class varies considerably from Geo Metros with a payload of 600 lbs to the VW Vanagan with a payload capacity of almost 2000 lbs.

3. Trucks,
such as the Chevrolet S-10, GMC S-15, Ford Ranger, Dodge Ram and Rampage, and VW Rabbit Truck. Trucks have the advantage of locating batteries outside the passenger compartment and typically have a frame which permits a higher payload capacity.

Each of these classes have their own characteristics with respect to aerodynamic drag, curb weight, Gross Vehicle Weight Rating (GVWR), passenger compartment, and available space for batteries.

Table 1 lists typical vehicles under each of these classes and their range using various lead acid battery packs (6V and 12V). Range is a function of battery weight because the battery represents the fuel. Typically it takes 15-20 lbs of lead to achieve 1 mile in range. A Rule of Thumb is that 1/3 of the EVs weight should be batteries; the other 2/3 represents dead weight (i.e. frame, suspension, body, motor, etc). If you could decrease this dead weight to 1/2 leaving 1/2 for fuel, you would have superior performance.

TABLE 1 - CLASSES OF VEHICLES

VEHICLE	*ICE CURB WEIGHT*	*VOLTAGE OF EV*	*BATTERY MODELED*	*CURB WT (LBS)*	*AVG RANGE (MILES)*	*MAX RANGE (MILES)*
SPORTS CARS						
Pontiac Fiero	*2530*	*120*	*5SHP*	*3360*	*44*	*68*
Honda CRX	*2175*	*120*	*5SHP*	*3060*	*47*	*72*
Toyota MR2	*2695*	*144*	*SCS225*	*3430*	*40*	*62*
Nissan Pulsar	*2025*	*144*	*SCS225*	*2863*	*46*	*68*
PASSENGER / VANS						
Ford Escort	*2300*	*96*	*T-145*	*3457*	*59*	*91*
Geo Metro	*1695*	*120*	*SCS225*	*2451*	*38*	*53*
Honda Civic	*2260*	*144*	*SCS225*	*3063*	*40*	*59*
Saturn	*2300*	*120*	*5SHP*	*3165*	*42*	*63*
VW Rabbit	*1930*	*96*	*T-105*	*2967*	*48*	*71*
VW Vanagan	*3460*	*120*	*T-145*	*4731*	*53*	*81*
Dodge Caravan	*3605*	*120*	*T-145*	*4854*	*52*	*80*
TRUCKS						
Chevrolet S-10	*2700*	*120*	*T-145*	*4100*	*61*	*92*
Dodge Ram	*2565*	*96*	*T-145*	*3682*	*51*	*76*
Ford Ranger	*2750*	*120*	*T-105*	*3908*	*44*	*64*
VW Rabbit P/U	*2200*	*96*	*T-145*	*3372*	*60*	*92*

Notes:
1. Calculations based on spreadsheet developed by Electric Vehicles of America, Inc.
2. Typically curb weight increases each model year
3. Average range based on 1 percent grade at 50 mph - representing some traffic.
4. Maximum Range based on 0 percent grade at 50 mph.

Other Considerations

Of course, there are other considerations, including:

Front Wheel Drive(FWD) vs Rear Wheel Drive (RWD).
A FWD vehicle has the advantage of being more efficient; which improves range. However, front wheel drive vehicles typically have smaller engine compartments which limit the location of batteries. Also, the front -wheel drive vehicle requires more weight (typically 60 percent) on the front axle. If you locate batteries in the trunk, the tail can wag the dog in rain or snow. This is a problem with many Geo Metros with batteries in the trunk.

In addition, the high voltage, high amperage EV controllers and motors can produce greater torque and horsepower than the original engine in the smaller FWD vehicles. This can produce a problem. There are two distinct limitations for FWD vehicle. During "launch"(initial take-off from a standing start) all cars tend to pitch up (front rotates up relative to back.) This is because the center of mass is above the force being exerted by the tires against the road. In a RWD, this pitch tends to plant the driven tires more firmly against the road, thus enhancing traction. In a FWD the effect is opposite. The force pressing the drive wheels against the road is reduced because of the pitch. If power is applied while the car is in a turn, RWD is much more stable. If the rear wheels spin, the car over-steers. If the front wheels spin, the car under-steers and may easily spin out.

Availability of Spare Parts / Age of Vehicle
Spare parts should be available. This availability is related to the production of that specific vehicle and which part of the country in which you live. Also the availability of after market parts for suspension upgrades can be important.

Manual Vs. Automatic Transmission
Most EV conversions are manual transmissions because they are more efficient than automatic transmissions and provide greater range, require less motor torque, require no transmission cooler, and are easier to convert. The problem with an automatic transmission is that it shifts at about 2000 rpm; the electric motor is usually designed to operate efficiently between 4000-5000 rpm. Consequently, the automatic transmission is a poor choice which results in decreased range. If you buy a vehicle with an automatic transmission, you can replace it with a manual transmission. The additional cost is $150 and up depending on the transmission and used auto parts dealer. Consider trading the automatic transmission.

Power Steering
Power steering is not recommended because of the continuous power required of the battery system. Even on many of the trucks that we converted, we eliminated the power steering. The cost to change from power steering to a manual steering box is under $100 and less than 1 hour of work. The equal weight distribution allowed reasonable manual steering.

Power Brakes
Power brakes are a definite advantage as you increase the weight of the vehicle approximately 800-1200 lbs with the EV components. In many cases, this represents an increase of 20 25 percent in the curb weight of the vehicle. Your goal should always be to have a safe vehicle. Power brakes unlike power steering are only an intermittent energy demand. A typical system requires a vacuum pump and a vacuum switch.

Curb Weight
Curb weight is the weight of the vehicle parked at the curb. No passengers and no payload. If you want to have 1/3 to 1/2 of the finished weight in fuel; then the initial curb weight of the vehicle should be less than 3000 lbs. The Geo Metro is one one the lighter vehicles with a curb weight of 1695 lbs. Consequently, an 800 lb battery pack seems ideal, except that GVWR and weight distribution become a major problem.

GVWR and Distribution
This is the most important consideration in any vehicle, because this directly affects the safety of the vehicle (Refer to "Safety First" in the September 1997 issue). As previously stated, converting an existing vehicle to an EV will add 800 - 1400 lbs in curb weight. Check the Gross Vehicle Weight Rating (GVWR) of the vehicle including the tires presently on the vehicle to see if it is designed for this increase. The GVWR and each axle rating are located on the drivers side door jamb. If the GVWR of the vehicle is exceeded, then the vehicle frame, suspension system, and braking system may be beyond their design value.

Although the Geo Metro can perform with an 800 lb battery pack, the payload capacity of the vehicle is 600 lbs. Payload equals GVWR minus curb weight. With two people in the Geo, the available payload decreases to 300 lbs. Consequently, an 800 lb battery pack can lead to braking and handling (See FWD vs RWD above) as well as a long term fatique problem with the unibody. Therefore, the lightest vehicle is not always the best vehicle.

You must also consider where the EV components will be located. Where will the batteries be located; they are the bulk of the additional weight. Will the charger be carried on board or off board? How will this change in weight distribution affect the vehicles handling? In the 1973 VW, the majority of weight was on the rear wheels; this was great for snow.

This further defined my requirements to:

A light-weight truck about 5 years old because it met my criteria developed in Step 1.
A manual transmission
No power steering
Power brakes

If my criteria was different, a different type of vehicle may have been selected. For example, if the most important criteria was acceleration to 50 mph. Then, the selection would be based on a vehicle with minimum weight and a low drag coefficient, i.e. a sports car.

STEP 3. SELECT ONE OR TWO MANUFACTURERS

It actually became easier as each decision was made. Here I searched through the available literature (Consumer Reports, Changing Times, Motor Trend, etc.) that provided detailed information on the weight and features of the different light-weight trucks available. Much of this information is now available on the internet.

These trucks varied in weight from 2555 lbs to 2900 lbs for the standard bed model; the long bed models add another 200 lbs. The lowest weight was the Dodge Ram 50 at 2555 lbs and the Toyota at 2565 lbs. Both of these trucks had an excellent reputations.

When I considered light-weight trucks, I evaluated the VW Rabbit P/U Truck, an oversize Rabbit. It had the advantage of being light-weight (2200 lbs) as well as front wheel drive to minimize drive train losses. It's disadvantage was that it had not been in production for 10 years and body rust was a problem in New England.

By doing this evaluation, my search was clearly focused. This eliminated time wasted looking at vehicles that did not meet my criteria.

My second EV conversion was a 1987 Dodge Ram 50 pickup converted in 1990 to 96V. This truck had a 5-speed overdrive transmission, power brakes, and rear wheel drive. The batteries are beneath the bed of the vehicle and the weight is over the drive wheels. This significantly improves their handling in snow. Its maximum range is 50 - 70 miles. Its maximum speed is about 65 mph.

My third EV was a Bradley GT II originally built as an EV. Surprisingly, this vehicle met my requirements developed in Step 1. This EV has been upgraded to the FB1-4001A Advanced DC Motor and Curtis 1231-8601 controller so that it will perform as a sports car.

My fourth EV was a GMC S-15 truck (same as the Chevrolet S-10). The advantages of the S series are:

1.The frame rails are further apart; this allows the battery box to be located under the bed between the drive shaft and the frame.

2. Both rear shocks are aft mounted so that you can 4-6 batteries forward of the rear axle. The number of batteries depends on the bed length and model year.

3. The front radiator area can easily accommodate 4 batteries.

4. The open channel frame is more to corrosion. Box frames can rust from the inside out.

We have since converted a number of vehicles (Dodge Caravan, Saturn , and more S-10s for electric utilities, U.S. Air Force, and Curtis Instruments.

CONCLUSION

In conclusion, consider the long term use of your EV. Here is a vehicle that you are going to invest thousands of dollars and approximately 100-200 hours of your time. Don't buy a vehicle just because it is available at a cheap price. You want to enjoy the vehicle and be proud to show it. Consider value not just initial cost.

It is important to state that a good conversion even after used for a few years can be sold, usually at a price greater than the cost of the components. A number of my S10 customers sold their EVs for $10,000 - $12,000 after driving them for a few years. How many internal combustion vehicles actually retain their value?

EVA's   1991 S-15
STILL ON THE ROAD !

We sold our S15 GMC for $20,000 after showing and driving it for 4 years! However, this EV was a really sharp vehicle and the workmanship was outstanding. It is still on the road with a very happy owner after many years!

Bob Batson

Electric Vehicles of America, Inc.
P.O. Box 2037
Wolfeboro, NH 03894-4223
(603) 569-2100
(603) 569-2115 FAX
EVAmerica@aol.com

www.EVAmerica.com