EVALUATING A VEHICLE FOR CONVERSION

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INTRODUCTION

In our paper "Selecting A Vehicle for Conversion", we give general guidelines for evaluating your needs in order to select one or two models that will work for you. In this paper, we provide general guidance to evaluate a specific vehicle. For example, will the batteries fit? Will I have problems as I interface with the electric system? Will this vehicle meet my needs? Will it meet the performance I require?

When "Selecting a Vehicle for Conversion" was written in the early 1990s, most cars and trucks were pretty simple. Since that time, vehicles have gained weight due to more safety features (airbags, side impact, ABS braking, etc.), more convenience features (heated seats, climate controls, DVD players, etc). This means more weight, more computers, and more complexity for those individuals looking to convert a vehicle to electric. Many conversions have been done; if available talk to someone who has converted the vehicle you are evaluating.

Older vehicles are usually easier to convert, but evaluating newer vehicles (less than 10 years old) is getting more difficult.

The objective of this paper is help the EV converter evaluate a specific vehicle before purchasing and stripping a vehicle for conversion. That is the wrong time to find out that your vehicle choice is a poor candidate. I am sure in many respects this paper is not complete; nor is it intended to be.

DISCUSSION

Let's look at some evaluation techniques:

- *Evaluate Battery placement and weight distribution*
- *Evaluate performance*
- *Evaluate drive train efficiency – coast down test*
- *Evaluate mechanical integration*
- *Evaluate electrical integration.*

We will look at each of these in more detail. As my example, I will use my 2004 Toyota Camry (4 cylinder) because it is available and not electric.

Evaluate Battery Placement and Weight Distribution

First compare the curb weight to the Gross Vehicle Weight Rating. The curb weight for the Toyota is 3270 lbs – very heavy for an EV conversion. The GVWR is 4189 lbs. This is given on the center post adjacent to the front driver's door. The GVWRF (front axle) is 2668; the GVWRR (rear axle) is 2668 also. The payload capacity is 900 lbs.

How will the batteries fit in the engine compartment and in the trunk. First, make cardboard mockups of the battery you might use. I like the new Trojan T-1275 (12V) because it has the weight (82 lbs) to provide good range. It is capable of 75 amps for 70 minutes; it uses thicker plates similar to 6V batteries so it can sustain higher amperages. The dimensions are 12-7/8 inches x 7 inches x 10-7/8 inches high. Making the mockups 13 x 7 x 11 inches is fine.

Evaluating the trunk for battery capability is fairly easy. The cardboard mockups clearly indicate that I can easily fit 10 batteries in the trunk. Possibly more. But the Camry is a FWD vehicle and placing to many batteries in the trunk will change the weight distribution so much that the tail could wag the dog. Batteries are required in the engine compartment.

The engine compartment is more difficult to assess. The engine is in the way so accessibility is limited. So take overall measurements. How big? How much space? Then identify the centerline of the engine; that will also be the centerline the be electric motor. Evaluate the distance from the face of the bell housing to the body structure of the vehicle at the opposite end. Is there space for the motor, adaptor plate and coupling? One of the advantages for our "clutchless design" is that less space is required for the adaptor plate and spacers;typically 1-1/2 inches or less. This is because we eliminate the pilot shaft which can require another ¾ inch to 1-1/2 inches of spacers.

For the 203-06-4001A motor one should allow 17 inches; for the FB1-4001A motor, one should allow 18 inches. This does not include the adaptor plate and spacers. To ensure adequate space let's use 2 inches. Therefore, we are looking at 19 inches and 20 inches respectively for the two motors. The Camry has just enough space for the FB1-4001A motor.

The "A" motors (auxiliary shaft) are the recommended motors because the auxiliary shaft can be used to drive an alternator, air conditioning compressor, power steering, tachometers, or more. It does add 2 inches approximately to the length of the motor.

Evaluating the potential number of batteries in the engine compartment is more difficult. The Camry motor centerline is 12 inches from the firewall and 17 inches from the front radiator cross-member. Fortunately, it appears that we can locate the batteries under the cross-member and possibly get three batteries up front.

So our conclusion is three batteries up front (246 lbs) and nine batteries in the rear(738 lbs). Typically, a FWD vehicle has 60 percent of the vehicle weight up front to maintain traction and steering performance. Basically, we are removing 15 percent of the vehicle weight (443 lbs). We will assume 100 lbs for the gas tank in the rear and the remainder in the front (343lbs).

	Front Axle	Rear Axle	Total
Original	**1962**	**1308**	**3270**
Removal	**390**	**100**	**490**
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Weight after Removal	*1572*	*1208*	*2780*
Added weight			
Motor, etc	*170*	*0*	*170*
Control Board	*50*	*0*	*50*
Batteries, etc	*270*	*770*	*1040*
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Weight after Conversion	*2062*	*1978*	*4040*
Weight Distribution	*0.51*	*0.49*	

You can very clearly see how the performance will be changed. Before we go further, it should be clear that we are estimating the changes. This is a best guess as to what could be. There will be changes when and if the conversion is done. Four batteries may fit in the engine compartment, the control board may be heavier, etc. Plus we have not considered people. The driver and passenger will add more weight distribution to the front axle.

Evaluate Performance

This is the easy part – just contact EVA (Electric Vehicles of America, Inc.) We will provide calculations based on the vehicle, batteries selected, and application. Here's a sample calculation for the Toyota.

2007 SEPTEMBER **ELECTRIC VEHICLE CALCULATIONS**
2004 TOYOTA CAMRY **PREPARED BY**
ELECTRIC VEHICLES OF AMERICA, INC

VEHICLE DESCRIPTION				**SYSTEM DESIGN**
INITIAL CURB WEIGHT (LB)	3270		1. MOTOR	FB1
FINISHED VEHICLE WEIGHT (LB)	4114		2. BATTERY	T-1275
DRAG COEFFICIENT	0.35		3. 20 HR RATE	150
FRONTAL AREA (SQ FT)	18		75 AMP RATE	70
TIRE SIZE			C FACTOR	0.87
RR RADIAL TIRE	0.01		4. VOLTAGE	144
REV/MILE (HIGH GEAR)	900		5. MOTOR EFF	0.88
			6. DRIVE EFF	0.9
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RESULTS OF CALCULATION	**HP REQUIRED**		**ESTIMATED MIN**	**RANGE AVG**	**(MILES) MAX**
(BASED ON 50 MPH - 2% GRADE)	**24**		**29**	**40**	**62**
********************************	********	********	********	********	********
SPEED (MPH)	**20**	**30**	**40**	**50**	**60**
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DRAG (LBS)	6	15	26	40	58
ROLLING RESISTANCE (RR)	41	41	41	41	41
TRACTIVE FORCE (0% GRADE)	48	56	67	81	99
GRADE FORCE + Tf					
0% GRADE	48	56	67	81	99
1% GRADE	89	97	108	123	140
2% GRADE	130	138	149	164	181
5% GRADE	253	261	273	287	305
WHEEL TORQUE, FT-LBS	*******	*******	*******	*******	*******
0% GRADE	44	52	62	76	93
1% GRADE	83	90	101	114	131
2% GRADE	121	129	139	153	169
5% GRADE	236	244	255	268	285
REQUIRED MOTOR HP	*******	*******	*******	******	*******
0% GRADE	3	5	8	12	18
1% GRADE	5	9	13	18	25
2% GRADE	8	12	18	24	32
5% GRADE	15	23	32	43	54
CURRENT REQUIRED (AMPS)	*******	*******	*******	*******	*******
0% GRADE	17	29	47	71	104
1% GRADE	31	51	75	107	147
2% GRADE	45	72	104	143	190
5% GRADE	88	137	190	250	319
AVAILABLE MOTORING TIME (MINUTES)		********	********	********	********

0% GRADE	336	190	116	75	49
1% GRADE	178	107	70	48	33
2% GRADE	120	73	49	34	25
5% GRADE	59	36	25	17	13
CALCULATED RANGE(MILES)	********	********	********	********	********
0% GRADE	112	95	77	62	49
1% GRADE	59	53	47	40	33
2% GRADE	40	37	33	29	25
5% GRADE	20	18	16	14	13
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Evaluate Drive Train Efficiency – Coast Down Test

It is pretty easy to obtain the miles per gallon (mpg) comparison of any vehicle. Naturally you want vehicles that have good mileage (greater than 20 mpg). But the question is what portion is due to the engine and what portion is due to the drive train. So the following test is proposed.

Drive the vehicle in 4th gear to 50 mph on a fairly flat portion of highway. Take your foot off the accelerator and coast to 30 mph. Record the time in seconds that it took to coast down. Repeat the test in the opposite direction to correct for changes in elevation. Then average the two numbers. Typical numbers are:

later

Evaluate Mechanical Integration

If you think about it, there is basically only one point of mechanical interface – the motor to bell housing. Make sure the motor will fit and that attachments to the existing engine will not be a problem.

This can be difficult and may require a mechanic's knowledge. So ask around. If someone has converted a similar vehicle, ask them what problems they had. Were there interferences? Is there adequate space for the engine, adaptor plate, and spacers? What would they do different?

For example, Mike Moore of Ampmobile Conversions has stated that on Toyota conversions there is a problem with the stub axle attached to the engine block. This can be a problem because it has to be in line with a specific tolerance and the engine block is removed.

<u>Evaluate Electrical Integration.</u>

Today's cars are more complex. We converted a number of 1988 S-10s for the USAF, and we converted a 1994 S-10 for Curtis Instruments. In those 6 years, the amount of wiring tripled due to on-board computers, electric speedometers, emission monitoring, etc.

The best advice is to obtain a copy of the electrical schematics for the vehicle you are evaluating. The main interface is the ignition system. Instead of starting the starter motor, the ignition key will turn on the main contactor. But there are other electrical interfaces that must be considered.

CONCLUSION

There are many vehicles that have been converted to electric over the last 20 years. Thes include VW Rabbits, Ford Escorts, Saturn, S-10 conversions, and many truck conversions. Many of these vehicles were originally built in the 1980's and early 1990s when vehicles had fewer computers and safety features. Most of these vehicles are no longer in production, so their availability or even the availability of spare parts is decreasing.

Today, people want to utilize a newer vehicle for their electric conversion. This transition will occur even more as newer battery technology develops and the availability of gasoline decreases (higher prices). The commuter will want a vehicle that has many of the conveniences of his internal combustion vehicle; the mother will want a safe and reliable vehicle for getting around town or taking the children to school. The early adaptor will want a vehicle that shows the way to the future.

Evaluating a specific vehicle for the application will become more critical for EV conversions.

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