How much Motor Hp will you need?

Selecting and calculating the right motor for your vehicle depends a lot on the weight of the vehicle, where you live. and the surrounding terrain. If you live in a hilly or mountainous local you will need more horsepower than if you live in an area where the grade is flat. It is also dictated by the vehicles aerodynamic profile before and after the conversion and its intended end use. A simple commuter vehicle driven in normal city traffic will require a much cheaper motor than someone who wants to win a race or have fast acceleration. There are many other variables. This motor primer is something that is intended to help you understand how much motor Hp you will require.

Here are some helpful hints on things that you should consider when selecting a motor and a controller that will match the motor.

Speed: Your speed will be mainly be determined by the voltage in your battery pack. In a DC motor 144 volts will usually get you freeway speeds of 70 + miles per hour.

Range: The available power stored in the batteries will determine the distance that your car can go before you need to recharge. Power is a calculation of the voltage in the battery times the amperage in the battery times the useful power available in the battery without damage to the cells. Battery chemistry determines this figure. This does not mean that you cannot discharge the battery lower than these figures. To get the maximum life out of a battery cell then these figures should not be exceeded.

Lead Acid Batteries ------ Voltage x Amperage x .55% = Usable Available Power.

Lithium (LiFePO4) Batteries ------ Voltage x Amperage x .80% = Usable Available Power.

Horsepower Rule of Thumb: It will take between 6 and 8 Hp for every 1000 pounds of finished converted vehicle that is on the road. This is assuming the terrain is fairly flat with occasional grade changes of no more that 2%. You can usually find the gross vehicle weight printed on the sticker inside the door jamb of each vehicle.

Regeneration: There is a great deal of misinformation floating around about the ability to recover power when the vehicle is slowing to a stop or going down a hill. This has been perpetuated by uninformed car sales people who are trying to capitalize on regeneration in order to sell more hybrid cars. Here is my take on this matter. It is very difficult to get regeneration from a DC motor. With an AC motor you will probably never get even 10% of your power recovered through regeneration. Consider 15% tops. If you want to install an AC system with regeneration your system will cost substantially more that the more basic and straightforward DC conversion.

Hp Required Formula: Rolling Resistance (hp) + Aerodynamic Drag (hp) + Hill Climbing ((hp) + Acceleration (Hp)

Rolling Resistance is typically 1% for every 1000 pounds of vehicle weight on level ground traveling at a speed of 25 MPH. Or 1.5 HP for each 1000 pounds of vehicle on level ground. Thus a 4000 pound vehicle would require a minimum of 6 Hp. 4000 x 1.5 Hp =6 Hp.

Aerodynamic Drag: is a function of the speed squared and the frontal area. Your drag goes up exponentially. Meaning that if you drive a very aerodynamic shaped vehicle the drag may be about .7 Hp at 25 MPH. If you drive the vehicle at 50 MPH the drag is increased to a little under 3 Hp. Most older cars have a drag coefficient less that the more aerodynamic cars of today so it would generally mean that you can figure a drag of 1 Hp at 25 MPH and something over 4 Hp at speeds over 50 MPH.

Hill Climbing: Hills naturally require more Hp. A 1% grade means that the elevation will increase 1 foot for each 100 foot traveled. You can use 1 HP for each percentage of grade. This calculation is the same as your rolling resistance. A 6% grade will require you to take 6 times the car weight rolling resistance to calculate the Hp required. (Remember that it takes 6 to 8 Hp for every 1000 pounds of car) Thus a 4000 pound car would require 4x6Hp x 2 or 48 Hp to push it 50 MPH up a 2% grade.

Acceleration: Electric motors have a great deal more torque at slow speeds than a internal combustion engine. The Automobile manufactures try to impress people with the Horsepower that their motor puts out. They rarely mention the fact that the engine is turning over 6000 RPM in order to get that Hp. Generally speaking it will only take about 13 electric motor Hp to maintain a 4000 pound vehicle at 50 MPH.

Watts Per Mile: My experience is that it is a function of all of the above calculations. For normal driving you can usually count on drawing less than 400 watts per mile with a 4000 Lb. car using lead acid batteries. The deciding factor is how much your batteries weigh. With lithium batteries your car will weigh much less so you can usually get something less that 300 Watts per mile. Very often below 250 watts per mile with lithium.

Lead Acid Batteries: Figuring a generally assigned number of 65 pounds for a standard flooded lead acid battery, it will take you 24 each 6.2 volt lead acid batteries for a 144 volt powered car. Because of their robust design a 6 volt lead acid battery will last more than a 12 volt battery of the same chemistry. You can figure between 300 and 700 charge cycles dependent on the quality of the battery and voltage of a lead acid battery pack. Lead acid batteries will lose as much as 40% of their available capacity in colder ambient conditions.

24 each 6 volt battery is x 65 pounds = 1,560 pounds and will yield 144 Volts.

A Trojan T-105 battery has a 20 Hour capacity rating of 225 Amps. 225A x 6.4V x 55% = 792 Usable Watts/Hr.

1,584 watts x 24 batteries = 19,008 watts or 19.Kilowatts. Giving the cautious driver, under somewhat ideal conditions, a range of 19000/400 = 47 miles

Lithium (LiFePO4) Batteries: The energy density of lithium is much greater than a lead acid battery. As a result they weigh much less than a lead acid battery. A 200 Ampere Hour 'AH' lithium battery will only weigh 16 pounds. However , you must remember that a typically lithium cell only produces 3.2 volts so you will need 2 of them at 8 pounds each (16 pounds) to give you the same 6.4 volts. Two lithium's in a pack packs will occupy about 45% the space of a lead acid battery and at 200 AH will carry nearly the same energy as the equivalent lead acid battery. Keep in mind that lithium has a capacity of 80% of their full state of charge. A lithium battery is not effected by cold temperatures nearly as much as a lead acid battery.

Thus 48 each time 3.2 volts times 100 AH batteries times 80% will have a usable wattage of 12,288 watts or 12.28 KW,

48 each 3.2 volt battery is x 8 pounds = 384 pounds. 23% the weight of the lead acid batteries. Consider this as a 144 Volt pack.

Because of this weight difference you can usually get about 50 miles range out of a 100 AH 144 Volt pack and about 100 miles in a 200 AH lithium battery pack.

Battery Economics:	Lead Acid	Lithium
Voltage	6.4 Volts	3.2 Volts
Amperage 'AH'	225 Amps	100 Amps
Usable Watts	792	256
Price each	$120	$120
Batteries Required	24	48
Battery Pack Cost	$2,800	$5,760
Battery Life	500 Cycles	2000 Cycles.
Cost Per kilowatt	$.00678	$.00426