

# NetGain Motors, Inc.

800 South State Street / Suite 4 / Lockport, IL 60441 / 630-243-9100 / 630-685-4054 (FAX)

## FAQ's

Last updated: May 20, 2014

Welcome to the *NetGain Motors, Inc.* Frequently Asked Questions (FAQ). This document will attempt to answer many of the questions that we are asked related to our products. It is not intended to provide answers to all your questions. We suggest you contact one of our **Authorized Dealers** for further assistance and guidance.

### Table of Contents

1. Where did the WarP™ name come from?.....	2
2. Which WarP™, ImPulse™ or TransWarP™ Motor should I use?.....	2
3. What is the difference between WarP™, ImPulse™, TransWarP™, and HyPerDrive™ Motors?.....	2
4. How do I become a dealer of WarP™ Motors?.....	3
5. What is an ICE, what is an EV, Hybrid?.....	3
6. What do the abbreviations "DE" and "CE" stand for?.....	3
7. What do the abbreviations "CCW" and "CW" mean?.....	3
8. What is "Timing" on an electric motor?.....	3
9. How do I know how much to advance the timing on a motor?.....	4
10. How can I order WarP™ Motors?.....	4
11. What if I need something other than the "standard" motor?.....	4
12. Where can I get replacement parts for my motor?.....	4
13. Can I put an alternator, generator, windmill or solar panels on my vehicle to keep the battery charged?.....	5
14. Can I use your motors in marine applications?.....	5
15. What are the two wires that come out of the motor case and how do I use them?.....	5
16. What is the round black connector on the commutator end bell used for?.....	5
17. What are TransWarP™ Motors?.....	5
18. Can I direct drive my vehicle using your TransWarP™ Motors?.....	6
19. How do Volts and Amps affect a motors performance?.....	6
20. What voltage and amperage should I run at?.....	6
21. What motor controller should I use with these motors?.....	6
22. How much power can these motors produce?.....	7
23. Where can I obtain an adapter plate made for my vehicles transmission?.....	7
24. Can I run the motors at 10,000 RPMs?.....	7
25. Where can I get additional assistance with my conversion?.....	7
26. What is the EVDL and how do I subscribe?.....	8
27. What components do I need to make an electric vehicle?.....	8
28. What makes a good conversion vehicle?.....	8
29. I want to go 300 miles on a charge at 75 miles per hour in my Suburban – okay?.....	8
30. I want to use a small generator to run the electric motor while I am driving on the highway.....	9
31. Can I use capacitors to power the vehicle?.....	9
32. Do I really need a transmission?.....	9
33. Should I keep the clutch?.....	10

1. Where did the **WarP**<sup>TM</sup> name come from?

We are not “trekkies”, but we do enjoy *Star Trek*. However, that had very little to do with the original name selection for our motors. The name was a natural way of differentiating our motor series, and also showed that we intended on incorporating new and advanced thinking in the enhanced designs of the motors we planned on building. The “**War**” portion of the name comes from a portion of the name of a motor manufacturer that was instrumental in our original designs (and subsequent designs, as were John Wayland and numerous others...). The capital “**P**” at the end of the name is also significant. It stands for “Phil Brown”, a close friend and supporter of our original electric dragster concept vehicle. Unfortunately, Phil was taken by cancer prior to the project gaining momentum. We intend to maintain this method of honoring Phil in the naming of our **Impulse**<sup>TM</sup>, and **TransWarP**<sup>TM</sup> Motors as well. The **Impulse**<sup>TM</sup> Motors are our line of AC powered motors, while the **WarP**<sup>TM</sup>, **TransWarP**<sup>TM</sup> and **Hyper-Drive**<sup>TM</sup> Motors represent our DC line of motors. All of the **TransWarP**<sup>TM</sup> motors have a 32-tooth involute spline shaft that matches the transmission output shaft of a Chevrolet Turbo 400 transmission.

2. Which **WarP**<sup>TM</sup>, **Impulse**<sup>TM</sup> or **TransWarP**<sup>TM</sup> Motor should I use?

The answer to this question depends upon MANY factors! We would be happy to discuss which motor we feel meets your needs the best, and to run your requirements through our motor selection software. The first question you should ask is: What is the intended purpose of the vehicle? Will it be used as a “daily driver”? Will it be used strictly for racing? Will it be a performance vehicle, or will it be designed for greatest range between charges? In addition to knowing the answers to these questions, you should have some realistic thoughts relating to:

- 1. Top speed to be maintained on level terrain \_\_\_\_\_
- 2. Top speed to be maintained on grade \_\_\_\_\_
- 3. Percent grade the vehicle will travel on \_\_\_\_\_
- 4. Wind resistance (frontal area) of the vehicle \_\_\_\_\_
- 5. Total vehicle weight (with driver/passengers/load) \_\_\_\_\_
- 6. Final gear ratio \_\_\_\_\_
- 7. Tire Diameter \_\_\_\_\_
- 8. Voltage to be supplied to the motor \_\_\_\_\_
- 9. Coefficient of drag \_\_\_\_\_
- 10. Battery internal resistance \_\_\_\_\_

3. What is the difference between **WarP**<sup>TM</sup>, **Impulse**<sup>TM</sup>, **TransWarP**<sup>TM</sup>, and **HyperDrive**<sup>TM</sup> Motors?

The **Impulse**<sup>TM</sup> line of motors were designed to be lower power and/or smaller motors than our traditional **WarP**<sup>TM</sup> series motors. The **Impulse 9S**<sup>TM</sup> is shorter than a **WarP 9**<sup>TM</sup>, and is less powerful. However, it is more powerful than the 8” diameter motor it was designed to replace. In addition to being more powerful than an 8” motor, it shares many of the beefy components of the **WarP 9**<sup>TM</sup> Motors (commutator, bearings, brushes, etc.). The **Impulse 9**<sup>TM</sup> also has the same bolt pattern and mounting characteristics of an 8” motor. The **WarP**<sup>TM</sup> Motors are our most common motors. The **WarP 9**<sup>TM</sup> and **WarP 11**<sup>TM</sup> were designed to be interchangeable with one another. The **WarP**<sup>TM</sup> Motors are the most common motors we make for EV conversions. The **TransWarP**<sup>TM</sup> Motors were

designed to meet the needs of direct drive, racing applications, as well as being used by **EMIS**™. The “rule of thumb” when dealing with direct drive applications is that #1 it is not good for use as a daily driver #2 it will require twice the motor and twice the controller of a vehicle with a transmission. Our latest offering is the **HyperDrive 9**™ motor. These are actually two specially race prepped **WarP 9**™ motors with different shafts, brush rigging, etc. from our normal **WarP**™ Motor. The **HyperDrive**™ is a set of two matched motors that are designed to be fitted together and work as a single motor. The “**Pe**” portion of the name is my thanks to Mike **Pethel** who helped fund the development of this radical design.

#### 4. How do I become a dealer of **WarP**™ Motors?

You should visit our Web Page (<http://www.go-ev.com>) and print a copy of the **Dealer Application**. Fill out the form completely and FAX it back to us. You must have a valid existing business with a state resale sales tax number in order to even begin the process. We also consider proximity to other Dealers, experience converting vehicles to electric, and other factors, web only Dealers will no longer be considered.

#### 5. What is an ICE, what is an EV, Hybrid?

**ICE** stands for **I**nternal **C**ombustion **E**ngine. **EV** stands for **E**lectric **V**ehicle. A hybrid vehicle is one that uses a mixture or combination of technologies to propel the vehicle. Hybrids are generally one of two types: series or parallel. A parallel hybrid uses multiple, possibly combined, means of powering the vehicle, while a series hybrid generally uses a source to produce electricity in order to power an electric motor that actually drives the vehicle.

#### 6. What do the abbreviations "**DE**" and "**CE**" stand for?

"**DE**" stands for "**D**rive **E**nd". This is the end of the motor that usually contains the fan and usually has a larger diameter shaft. "**CE**" stands for "**C**ommutator **E**nd". This is the end of the motor where the brushes and commutator are. Motors that are specified as "no **CE** shaft" do not have a shaft extending from this end. "**CE**" is also the abbreviation used by Dennis Berube for his world record holding electric dragster: Current **E**liminator.

#### 7. What do the abbreviations "**CCW**" and "**CW**" mean?

"**CW**" stands for "**C**lock**W**ise" rotation and "**CCW**" stands for "**C**ounter-**C**lock**W**ise" rotation. These abbreviations are normally used in conjunction with "**DE**" and "**CE**" to indicate the perspective of the armature rotation. For instance: "**CCWDE**" would indicate Counter-**C**lock**W**ise rotation when viewed from the **D**rive **E**nd – this is the default for all **WarP**™ Motors with the exception of the **TransWarP 7**™ which is neutrally timed from the factory (but may be ordered with advanced timing. **CWDE** would indicate "**C**lock**W**ise rotation when viewed from the **D**rive **E**nd. Most vehicles require **CCWDE**, however, some vehicles (i.e. Honda transmissions) may require **CWDE**. You should verify the rotation prior to ordering as the timing can be requested to be advanced timed for the rotation of the motor.

#### 8. What is "**Timing**" on an an electric motor?

Timing an electric motor refers to the area of the commutator that is being energized has been moved

from a normally centered position. Normally, brushes are fixed into a position on the commutator during the manufacturing process. The position they are normally set at from a manufacturer is a "neutral" position. A "neutral" position allows the motor to operate and perform almost identically in **CCWDE** and **CWDE** rotations at normal voltages. A normal voltage for most series wound motors in a neutral timed arrangement is generally less than 96 volts. Above this voltage motors should almost always be advanced in the direction of their normal rotation in order to reduce arcing, improve RPMs, and to provide increased performance at higher voltages. **CAUTION: If a motor is advance timed and then powered to run in the opposite direction of the advancement, significant arcing and damage could result if high power is applied! Regen should not be attempted with motors that have been advance timed!**

#### 9. How do I know how much to advance the timing on a motor?

All new **WarP™ Motors** have pre-drilled holes that allow the commutator end-bell to be removed and the brushes repositioned in a neutral, or an advanced position, either **CWDE** or **CCWDE**. The **WarP™**, **Impulse™** and **TransWarP™ Motors** are each advanced ~12 degrees. The **WarP 8™** motor is advanced ~10 degrees. The amount of advancement is based upon the width of the brushes, the number of commutator bars, the diameter of the commutator and various other factors that are monitored when the motor is run on a dynamometer. The proper terminology used to describe an advanced timed motor would be "advanced timed, **CCWDE**" or "advanced timed **CWDE**". The term "retarded" that is often used to describe the timing of **ICE (Internal Combustion Engine)** vehicles is not applicable to electric motors. In order to change the timing, you may simply loosen 4 bolts and rotate the bell housing in the direction you desire to advance the timing from the neutral position. All of our motor cases are stamped with "CW" "N" and "CCW" - you can determine the advance state by seeing which commutator **end bell bolt** is aligned with the letters stamped in the case. **THE TERMINAL STUDS SHOULD NOT BE USED TO DETERMINE POSITION OF THE END BELL!**

#### 10. How can I order **WarP™ Motors**?

**WarP™ Motors** may only be ordered through an Authorized Dealer. A list of Dealers is available on our web page at <http://www.go-ev.com>

#### 11. What if I need something other than the "standard" motor?

**NetGain Motors, Inc.** will work with our motor manufacturers in order to ascertain your specific needs and develop a motor to meet your needs. Custom motor options, such as special materials, components, shaft splining, special composition brushes, or other variances from standard configurations are available at an additional cost. We also have some motor models that we do not advertise (such as a Sep-Ex WarP 9). Additionally we make many private label OEM motors. Though we cannot sell these motors to anyone other than the OEMs, the designs may be similar to others needs and can keep the cost of a design within reason. Contact **NetGain Motors, Inc.** with your needs and we can provide a quote.

#### 12. Where can I get replacement parts for my motor?

Replacement parts and components can be ordered through any Authorized Dealer or directly from **NetGain Motors, Inc.**

#### 13. Can I put an alternator, generator, windmill or solar panels on my vehicle to keep the battery

charged?

In brief: "NO"! We receive this question on almost a daily basis! If you figure out a method of actually getting more energy out of something than you put into it – please let us know immediately! To date, no one has figured out how to accomplish this feat – and though you aren't going to receive a ticket for trying, there are certain laws that you would be in violation of. Though windmills and solar cells may certainly be used to help charge batteries, most of the motors we sell are for use in vehicles that can draw between 340,000 watts (for a short time), and 15,000+ watts at highway speeds. If you have the time and plenty of sunlight and wind, these resources could certainly replace at least some of the energy consumed – just not as fast as people generally use it, or as quickly as you may want.

#### 14. Can I use your motors in marine applications?

Certainly, but don't submerge them, and protect them from saltwater. Also, pay particular attention to previous question. It is extremely difficult to create a watercraft with 10-12 hours worth of wide-open power with generally available battery technology.

#### 15. What are the two wires that come out of the motor case and how do I use them?

These wires are connected to a normally closed 120C thermal switch. On 11” and 13” diameter motors a 150C thermal switch is used. This switch is used to determine whether a motor is nearing a temperature that could cause internal damage to the motor. Some people refer to this switch as a “nuisance switch”. We do not suggest that this switch be used to automatically disable the motor if a heat condition arises as circumstances may require driving the vehicle to a safe area before shutting down. Some people use this switch to keep a contactor open by applying 12-volts to the switch. If the voltage is dropped (by the switch opening), then a light could be lit, or a buzzer sounded to indicate a potential problem exists. The two wires were changed to a recessed plastic connector that has two 1/4” mail spades on newer motors. This makes it extremely easy to connect with. Additionally, the Normally Closed (NC) switch has been replaced with a Normally Open (NO) switch. This also makes it simpler to wire a warning indicator.

#### 16. What is the round black connector on the commutator end bell used for?

Some motor models have been made with a brush wear indicator. If you look carefully into the connector you will see that the round black connector actually accepts flat, female, tab connectors. When the brushes wear to a point where the brush wear indicator wire touches the commutator, **a voltage equal to the commutator voltage will be fed through the brush wear indicator connector**. As this could be a high voltage, appropriate care should be given if this connector is used. Once the brushes wear to the point where the wire touches the commutator surface it is necessary to replace the brushes quickly or damage to the commutator could occur from the indicator wire. This feature has been removed from most motors as it was difficult to use with the pack voltages of typical EVs.

#### 17. What are **TransWarP**™ Motors?

The **TransWarP**™ Motors are not a motor with a transmission. The Drive End (DE) of the **TransWarP**™ Motors have a 1.375”, 32-tooth, involute splined shaft that matches a Chevrolet Turbo 400 (T400) transmission output shaft. The drive end bell has been pre-drilled to accept an optional “shorty” T400 tail-shaft housing. The output shaft accepts an optional industry standard 1350 series slip-yoke for easy connection to almost any manufacturers drive-shaft (with matching 1350 series yoke. The

commutator end shaft has also been increased in size to 1.125" with a 1/4" key-way. This allows easy coupling of **WarP™** Motors to **TransWarP™** Motors . These motors were designed to be part of the **EMIS™** System which was also available from *NetGain Motors, Inc.* You can couple a **WarP™** Motor to a **TransWarP™** Motor of the same size for direct drive applications.

#### 18. Can I direct drive my vehicle using your **TransWarP™** Motors?

Our motors like to spin 2000-4000 RPMs. Running the motors at very low RPMs will generally draw significant amperage and not allow the fan to cool the motor. Direct drive works well in racing applications, however it is not the best choice for a daily street driven vehicle. The generally accepted rule of thumb is this: Direct drive will require twice the motor and twice the controller of vehicle with a transmission. This means you would have to use a **WarP 9™** coupled to a **TransWarP 9™** in an application where a single **WarP 9™** would normally suffice if a transmission was used. Additionally, if a single **Zilla 1K** controller could have been used, you will need a **Zilla 2K** for a direct drive application. Additionally, you must force cool air into direct drive motors if the normal RPMs of the driven vehicle are below 2000 RPMs.

#### 19. How do Volts and Amps affect a motors performance?

VOLTs=RPMs in an almost linear manner. If you double the voltage you will double the RPMs of the motor. Usually, RPMs increase just slightly more than double as most losses are fixed. You will notice that the performance graphs for our motors are all at 72 Volts. If you plan on running at 144 volts you can simply multiply the RPMs by 2. AMPS=Torque. Torque will remain constant if the amperage does not change, regardless of the RPMs. If you look at our 72 Volt graphs and find a ft. lbs. of torque and the amps required to produce that torque, you can simply double the RPMs if you are planning to run at 144 volts, - the torque will be produced at twice the RPMs if the amperage doesn't change. If you increase the AMPS, the torque will increase, but in a non-linear manner that is difficult to extrapolate. If you increase the voltage you will basically extend the torque curve of the motor.

#### 20. What voltage and amperage should I run at?

Your budget and performance expectations will normally be the deciding factor, but generally speaking, for a daily driver vehicle, you should consider a voltage between 120 and 156 volts to the motor armature. Motors should never see more than 170 volts to the armature (except when prepared for racing). However, the battery pack voltage should be as high as the controller will allow if using lead-acid batteries. You should generally have a higher pack voltage (ideally) than the motor voltage due to a condition referred to as "voltage sag". When most lead-acid batteries are requested by the controller to deliver 1000-2000 Amps to the motor, the battery voltage can easily sag to 5-5.5 volts per battery (on 12 Volt batteries). Lead-acid batteries have been known to explode during racing applications from heavy discharges – a credit to the **Zilla** controllers! However, if the voltage of a 12 volt PbA battery sags to 6 volts, the motor may only see ½ the voltage you intended, and consequently only spin at ½ the RPMs you thought it should! It's generally not the motor that is the reason for poor EV performance, it is more often related to the batteries or controller. (assuming the motor selected is appropriate for the vehicle...)

#### 21. What motor controller should I use with these motors?

For many years the only controller that was **ever** recommended in a pure electric vehicle application by *NetGain Motors, Inc.* were the **Zilla** Controllers from <http://www.cafeelectric.com>! The **Zilla** is still

available and is still a top-notch controller. Two more recently developed controllers are the **WarP-Drive** controllers manufactured by [ngcontrols.com](http://ngcontrols.com), and the **Soliton 1** by [evnetics.com](http://evnetics.com). Both of these controllers are excellent choices as well. You may certainly use other controllers, such as the ever popular **Curtis 1231C**, **Raptors**, **Synkromotive**, and **MaxForcer** – just to name a few of the more popular and highly regarded EV controllers. Your budget and vehicle performance expectations will be heavily impacted by the controller decision you make.

## 22. How much power can these motors produce?

Series wound DC motors, such as these, are renowned for the massive torque they produce from 0 RPM. These motors will suck every AMP the controller can deliver in order to try and start the armature spinning. Though our motors are regularly abused by **Zilla** controllers delivering 1000-2000 Amps, or Soliton Shiva capable of greater than 3,500 Amps for brief periods, the 9” motors (and 11HV) are actually rated at 450 Amps for 5 minutes, 225 Amps for 1 hour, and 190 Amps continuous duty. The normal 11” motors are rated at 500 Amps for 5 minutes, 250 Amps for 1 hour, and 200 Amps continuous. We believe these are conservative ratings. The difference in the variously sized motors is the amount of torque and RPM at which the torque will be delivered. If the ratings of a single motor are exceeded, you can divide the figures in  $\sim\frac{1}{2}$  and use multiple motors. There are additional losses of around 8-10% when using dual motors.

## 23. Where can I obtain an adapter plate made for my vehicles transmission?

Many **WarP™ Motor** dealers specialize in making transmission adapter plates, as well as providing the other components used in EV conversions. Our **Authorized Dealers** are listed on our web-site at <http://www.go-ev.com/dealers.html>. You can check the annotations in each Dealers listing to locate the best match for your specific needs. Some **Authorized Dealers** are capable of making adapters that are not listed on their web sites, so be sure to work with one of our **Authorized Dealers** for further information and advice.

## 24. Can I run the motors at 10,000 RPMs?

With no load and high voltage these motors can spin to excessive RPMs **EXTREMELY** quickly! The motors should **ONLY** be spun at no load with a maximum of 12 volts applied. The bearings are rated to  $\sim$ 14,000 RPMs, however we do not recommend running these motors beyond 5,500 RPMS (7,800 RPM for the 7” motors). For short durations (i.e. drag racing) the motors have been known to approach 10,000 RPMs, but this is strongly discouraged! If high RPMs are an essential requirement of your application you should consider requesting Kevlar banding and other optional modifications (belly banding) that can be performed at the factory or by a few of our **Authorized Dealers**. It is extremely dangerous to run these motors at high RPMs without shielding that can withstand a possible commutator explosion. World records have been set with these motors never exceeding 3,400 RPMs by gearing them properly. If extremely high RPMs are required on a normal basis a more appropriate motor design should be considered.

## 25. Where can I get additional assistance with my conversion?

An excellent resource is your local chapter of the Electric Auto Association. These groups have been doing conversions to pure electric for 40+ years and have extensive knowledge. Some of the Members of the EAA are world renown for their abilities. There are numerous books available, (i.e. **Build Your Own**

*Electric Vehicle* by Seth Lei <sup>TM</sup>an and Bob Brandt or *ICE FREE* by John Hardy) and most of our **Authorized Dealers** are willing to discuss your project with you and offer guidance advice at no cost. There is also a very active discussion group on the Internet called the EVDL (<http://www.evdل.org/index.h<sup>TM</sup>l>) and the DIY forums (<http://www.diyelectriccar.com/forums/>). Our **Authorized Dealers** are some of the best resources in the world. They have generally completed numerous conversions and will work with you to supply parts and insight into a vehicle conversion, as well as supplying you with the various components you'll need.

## 26. What is the EVDL and how do I subscribe?

The **EVDL** is the **Electric Vehicle Discussion List**. You can find all the details needed to subscribe and view the archives at: <http://www.evdل.org/>

## 27. What components do I need to make an electric vehicle?

You will obviously need an electric motor. You'll also need a motor controller, and a device to act as the throttle that will signal the motor controller as to the power requested - a 5K potentiometer is by far the most typical method, but the Hall Effect method is a safer/better alternative. You'll also need batteries. A battery charger(s), possibly a battery management system, possibly a transmission adapter plate, battery boxes/enclosures, a DC-to-DC converter, a transmission adapter plate, lots of cable, lugs, contactor[s], connectors, gauges and wiring.

## 28. What makes a good conversion vehicle?

First pick a vehicle you like that is in good condition. It is not uncommon for people to keep EVs for many years. As the weight of the vehicle will probably increase (I've never seen one that decreased if lead-acid was being used), consider the gross vehicle weight constraints. Choose a lightweight vehicle with strong suspension and brakes - sports cars and small pick-up trucks make ideal candidates. Do not change the ride height of the vehicle, or the ride characteristics. The heavier the vehicle, the more likely you are to be dissatisfied with the range and performance. Small pickup trucks make good candidates, as the batteries can be placed under the bed along the frame rails, and they are designed for carrying additional weight (i.e. Batteries). They also have brakes designed to stop the vehicle with the extra weight you may add.

## 29. I want to go 300 miles on a charge at 75 miles per hour in my Suburban – okay?

NO! The typical range of a lead-acid EV is 25-50 miles on level terrain – depending upon the batteries and weight of the vehicle. Even with the most advanced PbA battery chemistry currently available a 300 mile range is beyond current PbA technology. But, conversions using the various Lithium batteries currently available are claiming 75-150+ mile range. We are headed in the right direction, just not at 300 miles for conversion vehicles yet, though the Tesla Model S claims a range of 306 miles for it's 85 kWh battery pack. The same answer goes for recharging the batteries in 5 minutes – it won't happen for quite awhile. Tesla claims 58 miles of range per hour of charging and 20-30 minute charging at it Supercharger stations (which are also free for Telsa owners to charge at!) The PulsaR and QuasaR Power Distribution Units (PDU) from *ngcontrols.com* have the potential for even faster DC-DC dump charging at a theoretical 150 kW and 300 kW. Though the PDU may have this potential, most battery packs could not withstand this sort of input to the batteries. EV components must be matched for safe operation and usage – consult with a knowledgeable source or contact one of our Authorized Dealers

before attempting a potentially dangerous operation on an EV.

### **30. I want to use a small generator to run the electric motor while I am driving on the highway.**

At first this sounds plausible, but using \$5.00/gallon fuel (gasoline) to derive \$1.00 per gallon fuel (electricity) is only the beginning of the issues surrounding this. Generators are noisy. Most generators are not designed to operate in a mobile environment and fuel can spill from their tanks and create a hazardous situation. If you try to quiet the generator you may reduce its ability to produce electricity. When generators are running they typically produce more pollutants in one hour than 250 hours of driving an ICE. Even in a lightweight vehicle you will require around 150 amps at 144 volts to maintain 60 MPH – that's more than a 21 kW generator!

If the question is “Trains do it why can't a car?”. The simple answer is that trains run level, and straight as much as possible, with few stops, at a constant speed, and cost millions of dollars. Trains are not concerned about their 0-60 MPH time, or merging with traffic. It only takes a small fraction of the power needed to obtain a desired speed that it takes to maintain the desired speed. Additionally, steel wheels on steel tracks offer 1/50<sup>th</sup> of the rolling resistance of rubber on concrete. A typical EV will use 144 Volts and 500 to 1000 Amps to get started from a dead stop. This is 144 kW of power! This would require a VERY large generator – probably larger than the EV itself, and probably requiring more fuel than the original ICE vehicle. My suggestion is that if you really want to attempt this that you only use a generator when the vehicle is parked and not in motion.

### **31. Can I use capacitors to power the vehicle?**

Probably not entirely. Though capacitors offer very high power density, their energy densities are very low (the opposite of fuel cells). Super-capacitors (aqueous based) and ultra-capacitors (organic based) usually become a slave to the batteries. There is potential for the use of capacitors in EVs, particularly when used with regen braking, but regen braking should not be done with series wound DC motors. The use of capacitors might be beneficial in obtaining a speed, but probably doesn't make much sense to use them to maintain speed. If a DC-to-DC converter were used between a battery pack and the capacitors they might prove to be an excellent addition to an EV. See: [http://www.powershow.com/view1/26cee4-ZDc1Z/Hybrid\\_Advanced\\_Power\\_SourcesHAPS\\_Project\\_Highlight\\_VTB\\_Annual\\_Review\\_2002\\_powerpoint\\_ppt\\_presentation](http://www.powershow.com/view1/26cee4-ZDc1Z/Hybrid_Advanced_Power_SourcesHAPS_Project_Highlight_VTB_Annual_Review_2002_powerpoint_ppt_presentation)

### **32. Do I really need a transmission?**

Whether you need a transmission depends upon many factors. The short answer is “YES”, but depending upon the vehicle, there are instances where no transmission may be required. For instance, if you are planning on just racing the vehicle and not driving it on the street, then you may not need a transmission. But, the transmission can be used to keep the vehicle in its power-band and thus improve the vehicles performance. If the vehicle is extremely lightweight you may also consider not using a transmission. But, once again, there are caveats. The motors normally enjoy spinning 2,000 to 3,000 RPMs . Spinning the motor slower may not provide enough ventilation to the motor, causing it to run hot. Additionally, very low RPMs may cause the motor to use more amperage and run hotter. A forced-air cover-band is highly recommended along with an external blower than can force cool air into the motor if the motor is going to be run at low RPMs for considerable amounts of time.

The use of a transmission will normally allow you to achieve far better performance and reduce the risks

of motor damage due to poor cooling or high amperage. And, a transmission may also provide two other important items for you to consider beyond the gearing advantages:

- I. A transmission can act as a mechanical safety disconnect! In case of an emergency the clutch may be depressed, or the transmission shifted to neutral. These motors can be extremely powerful, and brakes alone may not be enough to stop a vehicle if the motor is applying force.
- II. A transmission can be used to park the vehicle. Some automatic transmissions have a locking feature (Park) that will keep the transmission from turning – and thus the car from moving if it is on an incline. In an ICE vehicle you always have the engine compression, emergency brakes and transmission (in Park) to keep the vehicle from moving on an incline. In an EV you should maintain a parking brake, but the motor will spin freely, so having a transmission that locks could be a benefit.

### **33. Should I keep the clutch?**

The EV community has always been split on this topic. Certainly it is easier to eliminate the clutch, and the electric motors normally have enough power so that a vehicle can start in 3<sup>rd</sup> gear without the use of a clutch. But, I personally prefer keeping the clutch. If starting on an incline without a clutch, the motor can be required to produce a lot of torque (draw a lot of amperage) depending upon the gear you start in. By using a clutch, it is easier on the motor as you can raise the RPM's and gradually get the vehicle moving. Keeping the clutch also makes it easier to shift gears. The EV community is split 50/50 on whether to keep the clutch. Be aware that if you keep the clutch and insist on driving it like an automatic (i.e. starting in 3<sup>rd</sup> gear) that it most likely you will burn up your clutch if you make repeated fast starts.