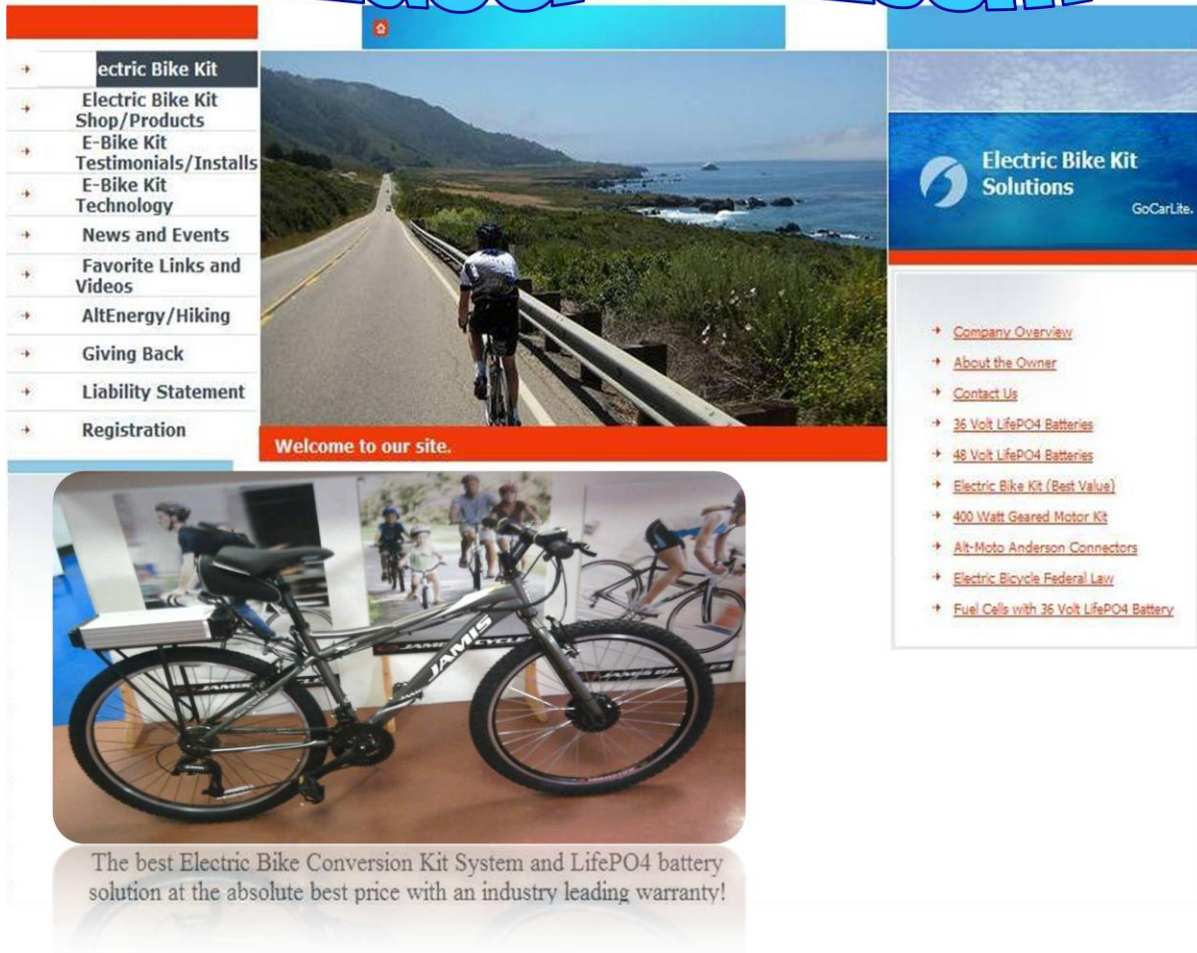


WWW.GOCARLITE.COM



The screenshot displays the GoCarLite website interface. On the left is a vertical navigation menu with the following items: Electric Bike Kit, Electric Bike Kit Shop/Products, E-Bike Kit Testimonials/Installs, E-Bike Kit Technology, News and Events, Favorite Links and Videos, AltEnergy/Hiking, Giving Back, Liability Statement, and Registration. The main content area features a large image of a cyclist on a scenic coastal road. Below this image is a red banner with the text "Welcome to our site." To the right of the main image is a blue header for "Electric Bike Kit Solutions" with the GoCarLite logo. Below the header is a list of product links: Company Overview, About the Owner, Contact Us, 36 Volt LifePO4 Batteries, 48 Volt LifePO4 Batteries, Electric Bike Kit (Best Value), 400 Watt Geared Motor Kit, Alt-Moto Anderson Connectors, Electric Bicycle Federal Law, and Fuel Cells with 36 Volt LifePO4 Battery.

Electric Bike Kit

- Electric Bike Kit Shop/Products
- E-Bike Kit Testimonials/Installs
- E-Bike Kit Technology
- News and Events
- Favorite Links and Videos
- AltEnergy/Hiking
- Giving Back
- Liability Statement
- Registration

Welcome to our site.

Electric Bike Kit Solutions
GoCarLite.

- Company Overview
- About the Owner
- Contact Us
- 36 Volt LifePO4 Batteries
- 48 Volt LifePO4 Batteries
- Electric Bike Kit (Best Value)
- 400 Watt Geared Motor Kit
- Alt-Moto Anderson Connectors
- Electric Bicycle Federal Law
- Fuel Cells with 36 Volt LifePO4 Battery

The best Electric Bike Conversion Kit System and LifePO4 battery solution at the absolute best price with an industry leading warranty!

ELECTRIC BIKE SOLUTIONS CONVERSION KIT OWNER'S MANUAL

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The Electric Bike Kit Solutions 36V/48V Complete System

is the ultimate electric bicycle conversion kit. The complete system has everything you need to convert your conventional bike into a high-quality electric bicycle. The complete system includes the Conversion Kit plus the highest quality LiFePo4 battery on the market with case, key, mounting plate and charger. This manual covers a complete conversion of your standard bicycle to an electric vehicle that can be used for recreation, commuting, and exercise.



The electric bicycle motor kit is supplied as a set of do-it-yourself parts for the user to install on his or her bicycle.

Because this kit is installed, maintained and operated by the purchaser, Electric Bike Solutions disclaims any responsibility for injury, damage or other consequences arising from the use of this product. Each



installation will be different and therefore it is the responsibility of the purchaser to determine the best way to install the kit on their particular bicycle. The following instructions should be considered as general guidelines only – your installation will be slightly different.

If you do not have the mechanical ability to correctly and safely install this kit, please obtain the services of a professional bicycle shop or other qualified technician. Installation and use of this kit will create a vehicle that has exposed moving parts, electrical connections and high powered batteries. Any or all of these components can be dangerous.

Always wear a helmet, ride responsibly and observe all Federal, State and Local laws.

Conversion Kit Box Contents:

- 1 x Front or Rear Wheel w/ Brushless Disc Brake Compatible Hub Motor (geared or direct drive)
- 1 x 36 Volt 22 Amp Intelligent Motor Controller (25 amp peak)
- 1 x Thumb Throttle
- 1 x Cut-off Switch
- 2 x Brake Handles w/ Electric Motor Cut-off Sensor
- 2 x Handle Bar Grips
- 1 x Battery Harness Wire (with kit or with battery)
- 1 x Owner's Manual with Installation Instructions

LiFePO4 Battery with case, keys, mounting plate, brackets & battery harness. Charger is included with Battery. Shipped separate from motor kit.

PLEASE CHECK ENTIRE CONTENTS OF BOX FOR PARTS AS THEY CAN GET TUCKED IN THE CORNERS.

36V/48V Conversion Kit Specifications

Motor: Direct Drive or geared Brushless Hub Motor

Power: 36v (up to 750w on demand / 20MPH) / 48v (over 1000w / 26 MPH)

Rim: Flat Profile Double-Walled

Spokes: 13 Gauge Stainless Steel

Weight: 14 Pounds direct drive/9 Pounds geared

Range: Range is dependent on battery capacity, weight of rider, route and pedaling. Customers with the light weight geared motor with a 36v battery are reporting that 30 plus miles is easily attained.

Pack Specifications:

Dimensions: 14" x 2 3/4" x 6"(10AH)
Weight: 11 lbs
Voltage: 36 Volts
Capacity: 10 AH
Cycles/number of Charges: 2000

BMS:

Over-Charge Protection: 3.85V per cell - 46.2v
(12 cells)
Over-Discharge Protection : 2.3V per cell -
27.6 (12 cells)
Max Discharge Current: 30A
Max Continuous Discharge Current: 20A
Short Circuit Protection: Yes
Balancing: Yes

Highlights:

- * Advanced compact BMS (battery management system)
- * Over Discharge Protection: To prevent damage to your battery, the BMS will monitor every cell in the battery pack. Over Charge, Over Discharge, Short Circuit Protection
- * Lightweight impact resistant aluminum battery enclosure
- * On/Off Key Switch: Locks battery box to rack system for added security



48v Rechargeable 9AH LifePO4 Battery Pack

48 volt 9 AH battery providing 33% more power with all the same or better features than the 36 volt model:

- Case, key, rack mounting plate, and 3 amp charger.
- Prismatic cells, 25 amp continuous discharge, 50 amp max.
- 3 amp aluminum case charger

Electric Bike Solutions Kit Installation Steps

IMPORTANT: You MUST only install a front hub motor on a bike with steel forks. It is important to tighten front wheels extremely tight when installing a hub motor and there is a strong likelihood of cracking anything but steel forks during installation. This could also be very dangerous if it happens while you are riding. Use your torque arms to eliminate the possibility of losing a wheel while riding and use steel forks to ensure your own safety. If you are unsure if your fork set is alloy or steel, test the fork with a magnet to ensure it's made of steel. If the magnet is NOT attracted to your fork it is NOT steel. Replace your fork with a steel fork or find another bike with a steel fork to convert. Electric Bike Solutions is not responsible for damages or injuries as a result of your installations.

Step 1 - Make Sure Your Bike is Suitable for Conversion

The Electric Bike Solutions conversion system is universal and can be used to convert most conventional bicycles. However, there are a few criteria which must be met first. Your front forks or rear dropouts need to be wide enough to accept the hub motor. Front forks MUST be at least 100mm at the dropouts (where the axle fits into the forks). Rear conversions require 135mm of space between the rear dropouts (these are standard for most bicycles) **For front wheel conversion your bike MUST have steel forks.** The motor is very strong and there is a lot of pressure at the axle. Aluminum is not meant to handle this kind of pressure and can crack. If your bike does NOT have steel forks and you want to convert using



a front wheel hub motor, you **MUST** replace your forks with steel forks or consider using a rear wheel conversion kit. Rear wheel systems are compatible with aluminum frames.

Helpful Tip: To test if your forks are steel, use a magnet. If the magnet sticks to the forks they are steel and you are fine to install a front hub motor kit. **You MUST use a Universal Torque Arm.** It provides increased support at the axle and is used to prevent the axle from ever "spinning out" inside the dropouts.

Step 2 - Install the Hub Motor Wheel

Take the hub motor wheel and place it between the forks (or rear frame drop-outs for rear kits) to make sure it fits correctly. Occasionally the forks must be spread slightly and/or the drop-outs need to be filed to snugly fit the motor axle. After making sure it fits, remove it and install the tube and tire from the old bike rim. For disc brakes make sure to remove the disc brake spacer bolted to motor, replace it with the actual disc and tighten. You can now install and secure the motor wheel in place. Make sure you secure the bolts tightly and secure a universal torque arm on front kits to keep the motor from spinning within the fork. If you apply power and the axle is not secured tightly, the motor will try to turn inside the dropouts, permanently damaging the wires connecting the motor. Inflate the tire, secure the brakes and flip the bike back over. Re-install and adjust the brakes. Odds are good that the new rim and old rim are not 100% the same, so adjust the brake pads so that they engage the rim with full contact. Adjust the cable for enough free-play to keep the shoes off the wheel during rotation. Disc brakes will usually require some adjusting as well. Electric bikes require more attention and care to brakes since you will normally be riding at higher speeds. Rear kits will require derailleur adjustments to work most efficiently with the six-sprocket cluster that comes attached to the rear kit motor.



Step 3 - Install the Throttle, Cut-off Switch and Brake Handles

Next remove the grips from the handle bars to replace the brakes and install the throttle and switch. The Electric Bike Solutions Kit includes two brake handles with internal magnetic switches that cutoff power and deactivate the throttle when braking. You will need to connect your existing caliper brake inner-wires to the brake handles. The On/Off Switch can go on the left or right side and needs to slide on the handlebars before installing the brakes. After installing the right-side brake lever assembly, slide the thumb throttle on. Slide your right handle grip back into place and then secure the thumb throttle with a hex wrench.

Step 4 - Install the Rear Rack & Secure Battery Pack

It is a little different for each bike, but generally when installing a rear rack you'll use the lower frame fender bolt holes for the lower support and the upper frame/seat post for the upper support. If you are using the Electric Bike Solutions 36v or 48v LiFePo4 battery pack it will come with a mounting plate that can be secured to your rack allowing you to easily slide your battery on and off and lock it in place when riding. Racks come in many styles so each installation will be different depending on the type of rack used. The following illustrates the optional rack sold with the Electric Bike Solutions Kits. Make sure your battery is secure and snug so it will not move when riding. If you are





unsure about how to secure the battery properly you should consult a professional.

Step 5 - Mount the Controller

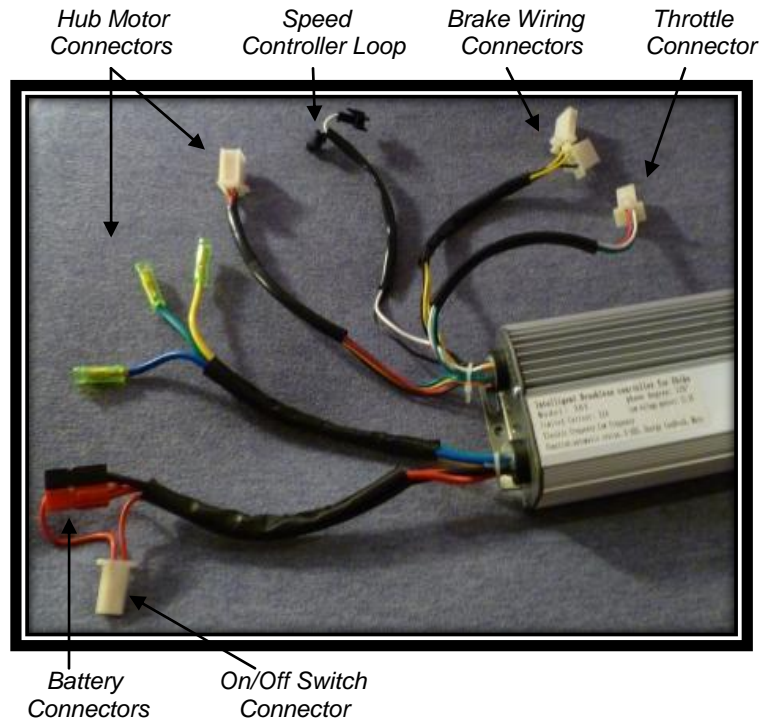
Now you have to decide where you would like to mount the controller. The most common places are behind the seat or on top of the battery. Be sure to keep the controller in a well ventilated spot to prevent Over-heating. A controller rear seat bag is also an optional item offered with the kit.

Step 6 - Run the Wiring

For a clean install, route all of the wires toward the back of the bike and secure the wires with zip ties. Make sure you have full range of motion with the handlebars when tying back the wires; leave some slack at each zip tie.

Step 7 - Connect the Electronics

Connect the wires from the motor, brakes, throttle, and on/off switch to the controller. The connectors from each component will only fit to the correct mate on the controller. Please consult the wiring picture for further clarification. Please note that there is a black & white "speed controller wire" on the controller that limits power to the motor when connected. This will limit the top speed of the motor to approximately 15 MPH. Simply disconnect the loop to enable full power and higher top speeds. When all connections are correctly and securely attached, plug your battery into the controller. If you're using your own battery and not the Electric Bike Solutions 36v or 48v LiFePo4 battery pack, you can use the wiring harness (included with the kit) to connect your battery pack.



Step 8 - Make Final Adjustments & Enjoy

Make sure the brakes are placed and tightened to your comfort level. Finally, make sure the brakes are adjusted, gears are tuned and everything is ready to go. That's it! Now you're ready to ride. **Be careful and take it slow until you get the feel. Ride for a few miles and then come back to check everything over. Give the bolts a good tightening one more time. You should check all the components often to make sure all connections are secure, especially near the hub motor.**

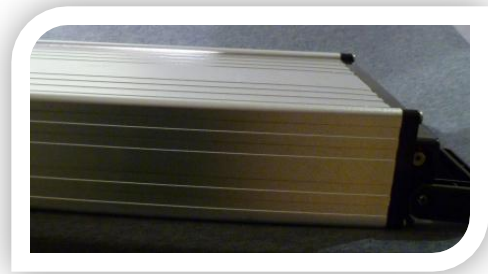
Electric Bike Solutions 36v LiFePO4 Battery Quick Reference Guide (same for 36v or 48v battery pack)

The 36v and 48v LiFePo4 battery packs provide the newest technology available. This battery pack has been designed for safety, ease of use and durability. Please take the time to read this manual before operating your LiFePO4 battery. It provides important instructions on how to properly operate and care for your battery pack in order to insure many years of reliable service.

Inspect your new battery:

- Keep all packing materials, foam insert and box.
- Inspect the pack, wires and charger for any visible damage, if you find anything, STOP and contact us, never use or charge a damaged battery.

Charging: Plug the charger into the wall first, and then plug the charger into the battery port. (The charge port is near/under the carrying handle). The 3 amp charger has two lights. One will be red when simply plugged into the battery. The other light will be RED during charging, ORANGE near the end and GREEN when fully charged. The 2 amp charger will have a red light during charging and a green light when fully charged.



IMPORTANT: For the first 5 to 10 battery break-in cycles, avoid deep discharges to allow the battery's cells to balance so that full battery capacity will be available going forward. Discharging the pack completely empty is not required. It is better to discharge the battery less than half way during the break-in period. In general, the battery will last longer if it is not being continuously depleted (charge it often!)

The charger will get warm during charging, do not cover the charger or leave it inside a bag, allow plenty of air for the heat to dissipate.

You can leave the charger plugged in for short periods of time (24 hours); this will not harm the battery. The "BMS" – Battery Management System inside the battery will prevent any possible overcharge, however, it is advisable to remove the charger once the pack has completed the charging cycle. This will extend the life of your charger.

IMPORTANT:

LiFePo4 batteries need to be stored fully charged and recharged no less than monthly. The charge dissipates over time. NEVER store your battery completely empty, this can cause permanent damage to the cells as they may slowly discharge while sitting below the pack's recharging capability. THIS KIND OF DAMAGE IS NOT COVERED UNDER YOUR WARRANTY. YOU MUST CHARGE YOU BATTERY AT LEAST ONCE EVERY MONTH WHEN STORING IT.

Plugging in the charger will recharge the pack to full capacity at any time. You can partially charge and disconnect the charger even if the green light has not come on and use the battery; be aware that you will not have a full charge.

WARNINGS:

- Always turn off/disconnect the battery from your E-Bike when not in use. If the motor is not running the controller consumes power on standby. Left connected long enough this can over-discharge the battery and cause permanent damage.
- Never use this battery for anything other than your E-Bike.
- Keep dry; the pack is water resistant, but not water proof. DO NOT SUBMERGE THE PACK IN LIQUID.
- SERVICE SHOULD BE PERFORMED BY A QUALIFIED BATTERY TECHNICIAN. NEVER OPEN YOUR BATTERY PACK.

Limited Warranty

All Electric Bike Solutions products have a one year warranty for parts and labor to the original retail purchaser when purchased directly from Electric Bike Solutions or an affiliate store. All warranties are effective from the date of purchase by the end user provided the product is purchased in NEW condition. Kits are covered for normal use against failure and defects, which does not include the following partial list):

"Over Voltage" - Connecting a battery with more than 60 nominal volts can damage the controller, wires and/or connectors. Damaging any kit component or motor by connecting the wrong battery type is not covered under our warranty. The Electric Bike Kit controller will work with any 36 volt or 48 volt battery pack. Using the controller with any battery voltage larger than 60 nominal volts will void the warranty for your kit.

Water Damage to the Battery/Improperly Caring for the Battery - The battery warranty does not include damage from power surges, use of improper charger, improper maintenance or other such misuse, or normal wear. Electric Bike Solutions Lithium Iron Phosphate battery packs are water resistant and fine in the rain but should NEVER be submerged in liquid.

- * **LiFePO4 Batteries need to be stored fully charged and kept in a dry environment.**
- * **Batteries should not be submerged in liquid for any reason.**

Warranties are limited to replacement of parts and/or products determined by Electric Bike Kit Solutions, at its sole discretion, to be defective. In cases where multiple components are missing, you may be redirected to the retailer for assistance. Electric Bike Solutions Limited Warranty does not cover or apply to the following: Normal wear and tear; any damage, failure and/or loss caused by accident, shipping, misuse, neglect, abuse and/or failure to follow instructions or warnings as stated on the product or in the applicable owner's manual or other printed materials provided with the product; damage, failure and/or loss caused by the use of the product for stunt riding, ramp jumping, competition, off-road use, acrobatics, trick riding or other similar activities, or use in any other manner for which such products were not specifically designed. This warranty does not apply to any products or components, mechanical and/or electrical, which have in any way been altered from their original configuration by any person. Electric Bike Solutions will not be liable and/or responsible for any damage, failure or loss caused by any unauthorized service or use of unauthorized parts.

Warranty Claims

Those parts and/or products which are determined by Electric Bike Solutions to be defective and to qualify for warranty replacement will be provided at no charge. Warranty claims must be made by the original purchaser by contacting the Electric Bike Solutions (1.707.439.3179) within the warranty period (stated above). Customer is responsible for shipping costs to Electric Bike Solutions. Electric Bike Solutions at its sole discretion, has the option of replacing with a new part, or factory re-certified part. The Limited Warranty stated herein is in lieu of and expressly excludes all other warranties not expressly set forth herein, whether expressed or implied by law or otherwise, including, but not limited to, any warranties for merchantability and/or fitness for any particular purpose. Electric Bike Solutions shall in no event be liable or responsible for incidental or consequential losses, damages or expenses in connection with their products. The liability of Electric Bike Solutions hereunder is expressly limited to the replacement of goods complying with this warranty.

Disclaimer

The Electric Bike Solutions electric bicycle conversion kit is supplied as a set of do-it-yourself parts for the user to install on their bicycle. Because this kit is installed, maintained and operated by the purchaser, Electric Bike Solutions disclaims any responsibility for injury, damage or any other consequences arising from the use of this product.

Each installation will be different and therefore it is the responsibility of the purchaser to determine the best way to install the kit on their particular bicycle. The provided instructions should be considered as general guidelines only—every electric bike conversion will be slightly different. If you do not have the mechanical ability to correctly and safely install this electric bicycle kit, you should obtain the services of a professional bicycle shop or other qualified technician. Installation and use of this e-bike conversion kit will create an electric motor vehicle that has exposed moving parts, electrical connections and high powered batteries. Any or all of these components can be dangerous! Always wear a helmet, ride responsibly and observe all Federal, State and Local laws.

United States Electric Bicycle Regulations

For reference only. Not legal advice. Be aware that electric bikes may be considered motor vehicles in some states. It is your responsibility to know the law. Federal law says that an electrically driven bicycle is considered a "bicycle" and the laws of bicycles apply if:

- 750 watt motor
- Functional pedals
- Max speed is less than 20mph

Sec. 1512.2. to read as follows: (1) A two-wheeled vehicle having a rear drive wheel that is solely human-powered; (2) A two- or three-wheeled vehicle with fully operable pedals and an electric motor of less than 750 watts (1 h.p.), whose maximum speed on a paved level surface, when powered solely by such a motor while ridden less than 20 mph.

Federal Public Law of "Low-Speed Electric Bicycles"

Federal Electric Bicycle Law
HR 727



SECTION 1. CONSUMER PRODUCT SAFETY ACT.

The Consumer product Safety Act (15 U.S.C. 2051 et seq) is amended by added at the end of the following:

LOW-SPEED ELECTRIC BICYCLES

SEC. 38. (a) Notwithstanding any other provision of law, low-speed electric bicycles are consumer products within the meaning of section 3(a)(1) and shall be subject to the Commission regulations published at section 1500.18(a)(12) and part 1512 of title 16, Code of Federal Regulations.

(b) For the purpose of this section, the term 'low-speed electric bicycle' means a two- or three-wheeled vehicle with fully operable pedals and an electric motor of less than 750 watts (1 h.p.), whose maximum speed on a paved level surface, when powered solely by such a motor while ridden by an operator who weighs 170 pounds, is less than 20 mph.

(c) To further protect the safety of consumers who ride low-speed electric bicycles, the Commission may promulgate new or amended requirements applicable to such vehicles as necessary and appropriate.

(d) This section shall supersede any State law or requirement with respect to low-speed electric bicycles to the extent that such State law or requirement is more stringent than the Federal law or requirements referred to in subsection (a).

"We recommend you laminate this sheet and keep with you when riding"

Electric Bike Solutions Technology

Hub Motor



Motor power ratings are specified in watts. $\text{Watts(W)} = \text{Volts(V)} \times \text{Current(A)}$. For example, a motor running at 36V and (x) 22A is pulling 792W. The thing that not everybody realizes is that motors don't have an exact value for watts. Consider the specified rating to be a general value as each motor will have a power range.

Sometimes motors are purposely under-rated as in the case of electric bikes sold to Europe, which by law are limited to 250W.

Ever wonder why there are so many motors rated for 250W? Taking one of these motors as an example, first calculate the current.

$250\text{W}/36\text{V} = \text{about } 6.9\text{A}$ That current is too low for 90% of ebikes so it doesn't add up. The lowest E-Bike controller current is at least 10A, and many are 15A or more. So $36\text{V} \times 15\text{A} = 540\text{W}$, twice what the specified rating

is. Of course you can run at a lower voltage, and 24V is still common, especially for smaller bikes. In that case you have $24\text{V} \times 15\text{A} = 360\text{W}$.

The point is that motors can be run at different power levels. They will be most efficient at a specific power level. Below this level, they will bog down and waste power for example when they are going slow under heavy load. At the higher point of the power range, the motor will start to get hot as it cannot dissipate the heat and will waste power.

The standard way to rate a motor is test it on a sophisticated motor testing apparatus. It puts it under measured loads and plots the various parameters including efficiency and output power. The power rating corresponds to the point of peak efficiency. There's actually a simpler method anyone can do. While not exact, it gets you in the ballpark. Simply increase the power level supplied to the motor while under load and measure the temperature of the motor. The power level at which point the motor is slightly warm when run continuously (under load) is the optimum operating level.

You will see motors advertised as 1000W on sites like Ebay and you might think, wow what a great deal on a powerful motor! The problem is any power level can be slapped on a motor. Most of these are actually 500W motors. Both our direct drive and geared motors operate very well at more than 1000W with a 48 volt battery (especially the direct drive); however, that is not where they operate most efficiently. They are most efficient cruising at 500W for the direct drive and 400W for the geared. So don't get caught up on power ratings or fooled by exaggerated advertising claims. For more information on your power requirements, contact us at 707-439-3179

Direct Drive or Geared?

There are two basic types of motors in wide use today for electric bikes, direct drive and geared. The direct drive has no internal gears or other moving parts except the actual case which rotates around the axle on sealed bearings. The coils are wound around an assembly that is fastened to the axle and remains stationary. The outer ring of the case has a ring of magnets that rotate in close proximity to the electromagnets formed by the coils. As the coils are energized in a specific pattern by the motor controller, the magnets are attracted and repelled causing the wheel to rotate. The outer case directly drives the wheel. The geared motor has the same basic configuration, but does not directly drive the case. Instead, there is an intermediate gear assembly driven by the motor. This consists of a free-wheel and three planetary gears which transfer the rotation to the outer case and wheel. The gear ratio is typically 4:1.

Geared motors are smaller and lighter. Due to the gear ratio, they have good torque, even at low speeds. Due to their small size and the physical strength of the gear assembly, there is a limit on the maximum power/voltage that they can handle. The internal free-wheel isolates the wheel from the motor so there is no resistance when turning the wheel.

Direct drive motors are bigger and heavier but can take more power. The bigger magnets and coils can accept higher current and voltage levels, and the larger size and mass can dissipate more heat. There are less parts in operation as they do not have the internal gear assembly. Depending on the motor, there may be some drag due to the magnetic attraction.

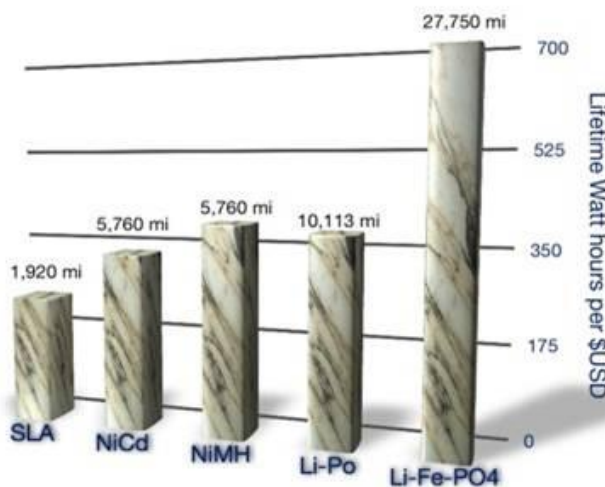
Which should you choose?

For riders who want assist but still want a light bike with the least amount of change in how it rides, the geared motor is best. It can get you up most hills with the right power level, but has an upper limit. It also is at least 15% more efficient, which means you will get more distance out of the battery per charge.

For high speed cruising over low to moderate hills, the direct drive works well. It can go faster than the geared motors and handles lots of power/voltage. If you can live with a heavier bike, you can load up with batteries and carry a heavy load very far and very fast.

Batteries

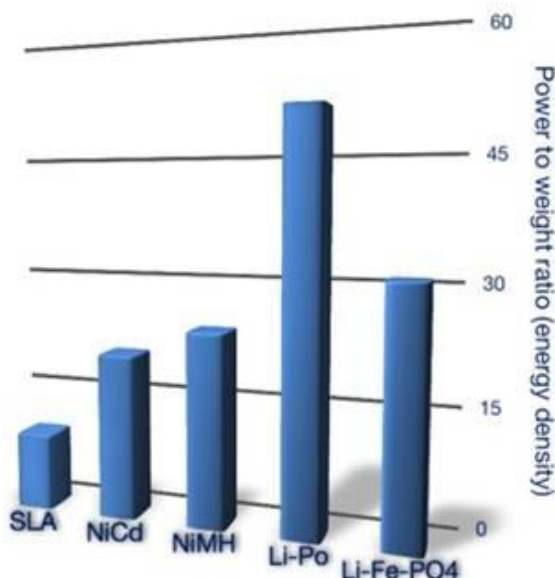
Batteries are the life blood of the electric bicycle and electric bike kit, and they come in many confusing forms. So as not to just present our own opinions, we will reference other sources as well to support what we know to be true.



This graph from electricbike.org.uk provides the best visual demonstration for why we choose the LifePO4 (lithium iron phosphate) battery technology. You get far more life out of this battery technology than any other.

"Lifetime energy carried versus cost, bigger is better. On top of the bars it shows approximately how far the battery will carry you over its life, irrespective of cost. The bars themselves show the cost-adjusted lifetime energy capacity. The Li-Fe-PO4 is about 2X more economical than the other batteries"

So why would anybody choose another technology? A number of things can be factored in that include up-front cost mostly, but as the previous graph demonstrates, LifePO4 technology is the most cost effective in the long run. That being said, lithium polymer (li-po) does present the most viable option because of its power to weight ratio. While the LifePO4 has a better ratio than the others, in essence the polymer will provide as much power with approximately 6 lbs of battery compared to 10 lbs for the LifePO4. So you just have to ask yourself if having four pounds less weight is worth double the price for a comparable battery life span. For some, it very much is.



On the next page is a very good brief discussion from lithiumstorage.com about the different lithium technologies. The article clearly hones in on the lifePO4 technology as generally the best solution. Realize that technology continues to get better for all of these.

All “Lithium” batteries are not all the same... yet they all seem to fall under the title “Lithium”. In fact over twenty different Lithium chemistries exist. Most of these chemistries fall under the grouping of Primary Cells like button cells and are not generally rechargeable. Under a separate category there are Lithium Ion, rechargeable, batteries. These Lithium Ion batteries are considered the best type for automotive propulsion. These are a type of rechargeable battery in which the anode (positive Electrode) contains lithium in some form while the cathode (negative electrode) is made of a type of porous carbon. In this category there are three general groups. These groups are made up of a wide variety of materials. These materials are as follows:

Layered Oxide: These batteries usually contain lithium cobalt oxide. Lithium cobalt batteries are considered a hazardous material and must be disposed of under strict guidelines. This type of battery is prone to explode if overheated during a rapid discharge or if charged to and excessively high voltage. (The authors opinion is to forget them as a candidate for your project).

Spinel: This group of lithium batteries contain minerals like manganese or cobalt. Batteries that contain these minerals are also considered to be a hazardous material with attendant disposal issues. These minerals lower the cost of the battery while sacrificing the battery life and depth of charge which will affect the vehicles driving range. Batteries that contain these minerals typically have about 1200 charge cycles before they reach 80% depth of discharge (DOD)

Polyanion: This lithium battery group contains lithium phosphate, also known as LiFePO₄. Lithium iron phosphate batteries are not considered to be a hazardous material (not necessarily true for shipping purposes). LiFePO₄ batteries are superior to other cathode materials in terms of safety, stability and performance and are available in larger energy density capacities than the other groups of batteries. LiFePO₄ batteries can exceed 2000 charge cycles before reaching 80% DOD. This figure indicates that a well made pure LiFePO₄ battery will exceed other lithium battery group’s life expectancy by an additional 33%! A good LiFePO₄ cell gives you much more bang for your dollars than the other two groups. However, in order to make a cheaper battery some companies will use lower grade materials to become more price competitive. The choice of materials and construction can dramatically affect the voltage, capacity, life, safety and cost of a lithium battery. All Lithium Ion batteries are sensitive to overcharge or if discharged below a certain voltage. To reduce this risk they all must have a circuit which shuts down the battery when it is discharged below 3 volts and charged above 4.2 volts. This circuit is referred to as a Battery Management System or BMS.

Advantages of Li-ion Technology

Lithium Ion batteries are lighter than other energy equivalent batteries – often much lighter. A key advantage of using lithium ion (especially LiFePO₄ which is “lithium-iron”) chemistry is the high open circuit voltage that can be obtained in comparison to aqueous batteries such as lead acid, nickel-metal hydride and nickel cadmium. Lithium ion batteries do not suffer from the memory effect. They also have a slow self discharge rate of approximately 5 – 10% per month compared to over 30% in common nickel metal hydride batteries and 10% per month in nickel cadmium batteries.

We also recommend reading another article from suite101.com at the link below. It does a great job of explaining *Lithium-ion versus Lithium-iron (it's much more than just the "r")...*
[Lithium-ion versus Lithium-iron \(more than just an "r"\)](#)



Battery Break-in

Lithium battery packs, especially LiFePO₄, have to go through a break-in period. The pack is made up of several cells connected in series, for example a 36V LiFePO₄ pack has 12 cells. When new, the cells do not charge and discharge at the same rate. One reason may be a chemical inhibitor that is added to slow down self-discharge. At any rate, there is a chemical process going on with-in new cells that cause them to perform differently when new.

Often the first thing a customer will do when buying a pack is to go out and really ride it hard to check the power and range. Unfortunately, that is not the best thing to do. It is recommended to perform 5 to 10 cycles of low discharges followed by full charges. A low discharge would be drawing 1-3 AH or riding 2-5 miles without heavy loads. Since the cells will discharge at different rates, the first cell to reach the minimum voltage will trigger the detection circuit in the BMS, which shuts off power. The range will be low and the customer thinks they have a bad pack. By doing short cycles the cells have a chance to equalize and not get far out of balance. The BMS has a balancing circuit, but it does not have the ability to bring up a cell that is much lower than the others. They have to be kept within a certain range of each other. In addition, leaving the pack on the charger over night gives the BMS time to equalize the cells. You may see the charge LED (green light) on the charger blink between red and green during this process. The pack is charged in "serial mode" where the charge current is passed through each cell to get to the next one. So each cell has to share part of the voltage going in, typically 44V for a 36v LiFePO4. During the critical break-in period some cells will accept current more than others. Thus, it is critical to follow the break-in process to optimize the performance of the pack.

Once properly broken in the pack will stay in balance if charged after each use and not left for long periods without charging. While rare, it is possible that a pack can become unbalanced even after being broken in. The solution is to charge up each cell separately until they are equal. This is not something the customer can do as working on the cells is dangerous. Not all suppliers have the technical ability to do this. At Electric Bike Solutions, however, we offer this service to our customers and can even replace individual cells in the unlikely event one goes bad.

So the bottom line is when you receive a new pack, for the first 5-10 times you use it, ride the bike only a few miles followed by extended charging.



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