The Grin Technologies Basics Ebike Guide

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Electric bikes are a new and promising alternative form of urban transportation. They provide all the advantages of a regular bicycle while eliminating one of the bicycle's main drawbacks, lack of power. You can pedal normally and just use the motor to help out on hills and headwinds, or use the motor all the time just to make riding easier and faster.

An electric bike normally comprises 4 key components:

Electric Motor

We mostly sell hub motor conversion kits where the motor is built inside the bike wheel and the axle of the motor is secured in the bicycle dropouts. The axle is fixed to the bicycle fork and then when you provide power to the motor the "rotor" part of the motor spins, which then spins the bicycle wheel itself.

Motor Controller

The motor controller delivers and regulates power to the motor, controls how fast the motor spins (via a throttle normally) and converts the DC (direct current) type of electricity the battery provides into the AC (alternating current) electricity needed to spin the hub.

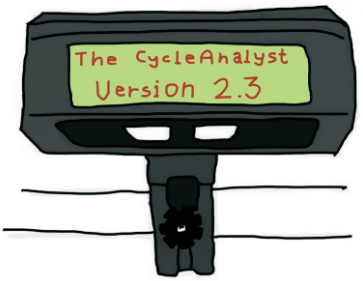
Throttle/Pedal Assist

The throttle is normally mounted on the handlebars of the bike and a twisting action tells the motor controller to supply more power. Some electric bikes have a pedal assist system (PAS) instead whereby your pedaling effort is sensed and this tells the motor controller to provide a certain level of assist power.

Battery

The battery is where the system gets its power from. Nowadays most ebike batteries are lithium batteries, similar to those found in laptops but are about 10x the size. The battery is usually recharged by a charger plugged into a mains power outlet. A battery weighing around 4kg can provide upwards of 20-40km range with speeds of 30-40kph depending on how much the rider pedals.

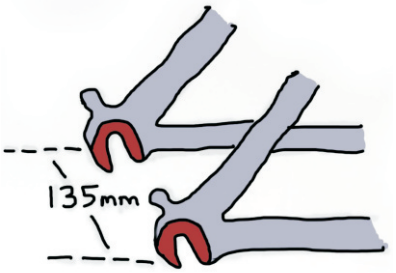
Many electric bikes also come with a display console so that you can view the performance of the ebike whilst riding. At Grin Technologies we design and manufacture the Cycle Analyst: it allows you to keep track of the vehicle's battery usage and performance characteristics, and with the more recent Version 3 model you can also monitor the throttle, the motor temperature, control pedal assist systems and much more. The Version 3 Cycle Analyst effectively becomes the “brains” of the ebike, and is able to control much of the electric bike ride behaviour.

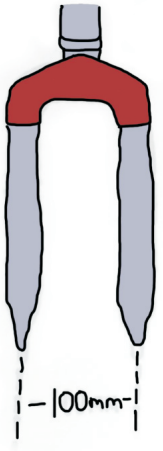


Considerations when buying an electric bike conversion:

Will it fit?

Our goal at Grin is to make ebike conversion parts as compatible as possible with regular bike standards. To that end all of our front hub motors have 100mm dropout width which is the industry standard for front forks and they fit in the vast majority of bikes. The rear wheels have 135mm axle spacing, which is standard for most bikes as well. Occasionally if you want to fit a larger 7, 8 or 9 speed freewheel on a rear motor then you need to space out the axle with some washers but most bike frames can be widened a few mms to accommodate this. We have also taken the time to create complete engineering diagrams for nearly all the hub motors we sell and these can help confirm the fit.





Our front motor axles are 12mm diameter machined to 10mm on the flats whilst the rears are 14mm diameter and 10mm on the flats. This means they will fit in most bike dropouts but in about half the forks out there a small amount of filing is required to make the dropout slot wide enough to fit the axle. If you have lawyer lips you might also need a C washer so that the motor nuts can be tightened flat against the dropout.

Front vs Rear:

For the most part you won't notice a huge difference between front and rear installations but a few factors to consider include:

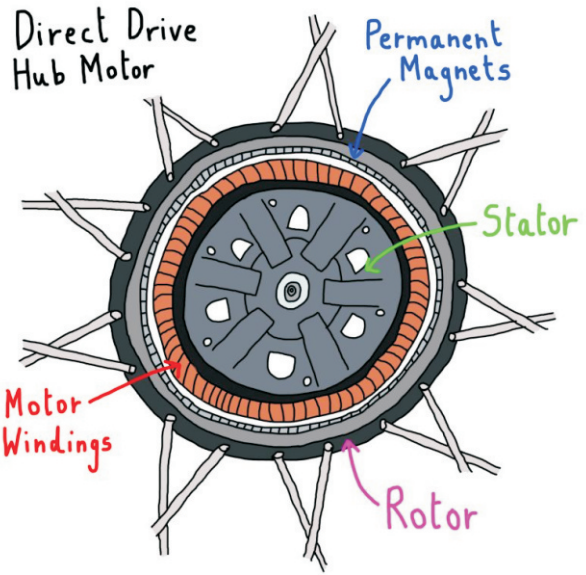
- **ease of installation:** a front tends to be easier than a rear
- **weight distribution:** with the battery normally mounted at the rear of the bike a front motor can help with more even weight distribution
- **traction:** front motors are limited in how much power they can deliver to the wheel on loose gravel roads without skidding since most of the weight is on the rear.
- **discreteness:** rear motors can be hidden with panniers to look more subtle

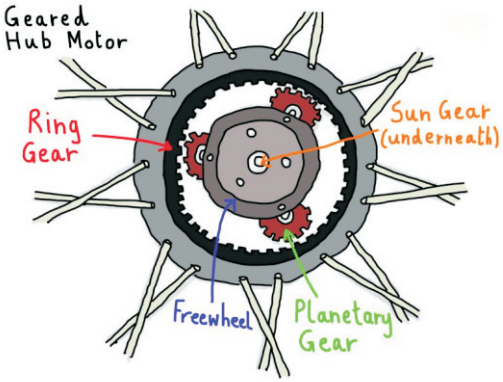
Regenerative Braking:

With a direct drive hub motor, you have the capability to use the hub as an engine brake as well, and have the motor to slow you down while charging up the batteries a bit in the process. The amount that regenerative braking recharges the battery can't really compensate for the battery discharge over the course of an ebike trip, usually about 5-10% recaptured, but it is definitely useful for saving wear and tear on the brake pads.

Direct Drive And Internally Geared Hub Motors:

In a normal direct drive motor the motor is always mechanically engaged which means you feel a slight resistance when turning the wheel. It amounts approximately to the difference between riding with a slick road tire and a knobby mountain bike tire.





Geared hubs have a high RPM motor inside with a planetary transmission linking it to the low speed of the bike wheel. They also have a built-in freewheel that disengages the motor so that the wheel spins freely with no drag when not in use. Together these make for a lighter hub motor and a ride experience that is closer to a normal bike, but because of the freewheel they cannot do regenerative braking.

Torque Sensing/Proportional Assist:

Most of our bike conversions are by default set up with a throttle input that controls the speed of the motor. However it is possible to have an assist setup, where the harder you pedal, the more motor assistance you receive. This has the advantage of removing the need to worry about engaging the throttle the whole time but also removes some of the control you have over the power delivery.

Waterproofing:

We spec and design our components with waterproofing in mind, and nearly all our own products cope well in rainy conditions. We endeavor to make the third party products we sell as waterproof as possible but some of them might get damaged from prolonged exposure to the elements. Water entry does occur in hub motors from time to time and it's generally advised to try and store the bike out of the rain if you can.

Freewheels:

All the rear motors we sell at Grin are able to accept a standard bicycle freewheel (though not a cassette hub which is different) and these are normally available from a bike store but usually with a limited selection. Alternatively we have a range of freewheels with 11 teeth on the smallest sprocket and this allows you to keep pedaling with the ebike even as it gets up to a higher speed from the motor power.

Disc Brakes:

The motors we sell are all able to take disc brakes with standard spacing, albeit with the Nine Continent motors having a narrow clearance and therefore needing a thin profile.

Making a final decision:

It's a good idea to make a list of key features that you want from your build before deciding on the components. Ask yourself questions such as:

Do you care about the weight of the bike? Are you looking for a fast top speed, or great hill climbing ability? Do you want the motor to freewheel when not in use? What kind of range do you want from the battery? If you want a high amperage controller do you have a battery and motor capable of handling the high power levels without being damaged?

Finally, make use of the ebike simulator on our website to get a good idea of the characteristics of different setups and to help make an informed decision and don't be afraid to ask us if there's anything you need help with!

For the remainder of this guide we will go over some commonly used electric bike terminology and explain what each term means....

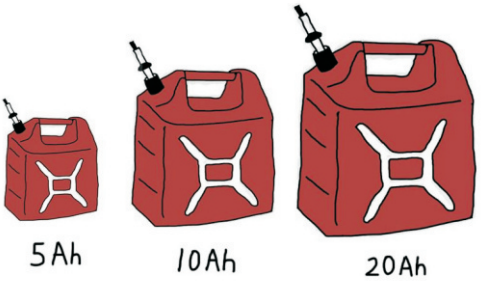
Ebike Glossary:

When we talk about electric bikes it is quite common to refer to electrical terms that may not be familiar to those without an electronics background. Here's a list of the most commonly terms with an short explanation to help your understanding of electric bikes.

Battery terminology

Amp-Hours (Ah):

Often confused for amps, the amp-hour rating of a battery is a measure of the total electric charge stored inside the battery, analogous to a car's gas tank. The larger the amp-hour rating in general the further you would be able to go on a single charge of the battery.



Amps (A):

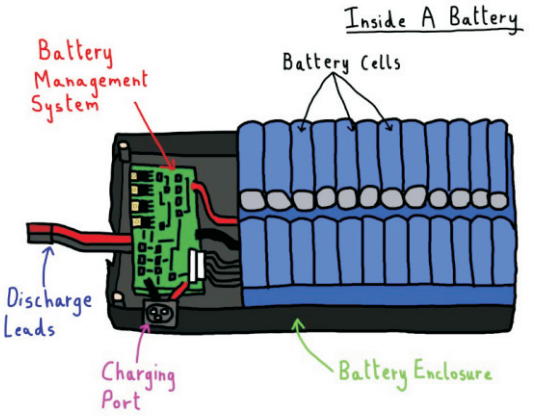
Amps is a measurement of the amount of electrical current flowing through a system. When you use a battery to power an electric bike amps flow from the battery to the hub motor via the motor controller. The larger the number of amps flowing, the more power you will be supplying to the motor. For example, a bike that has a controller limited to 35 amps (A) will climb a hill with more gusto than a bike with a 20A controller (everything else being equal). The downside is that you will drain the battery faster. For example, if you were drawing 10A from a 10Ah battery you would drain the battery in about an hour, whereas if you were drawing 20A you would drain the battery in about half an hour. If you increase to a higher amperage draw controller it will improve the acceleration and low speed torque but it won't affect the top speed of the bike.

Voltage (V):

Voltage is a measure of the electrical force available to push electricity through a circuit. Voltage is just like water pressure in pipe, and the more pressure you have available, the more water flow (amps) will pour when you open the spigot. With an electric bicycle, going to a higher voltage will mean more power can be pushed through the motor resulting in more torque off the line. Electric motors also generate their own voltage as they spin up which fights back against the battery voltage and so a higher battery voltage will also mean a faster top motor speed too.

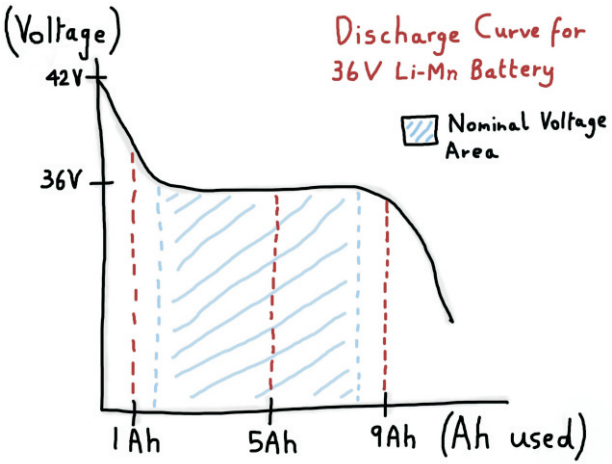
Battery Management System (BMS):

Ebike batteries are collections of smaller cells linked together to provide a certain voltage and capacity. The battery management system (BMS) sits between the cells and the "outside world" and helps to stop the cells from being damaged. It typically includes protection against over-charging (if the voltage is too high), over-discharging (if the cell voltage is too low), over-current (if the current is too high during charge or discharge) and short circuits. It often can help prevent discharge if the temperature is too high or low, and can also help balance the cells to ensure they all stay at the roughly the same voltage during charging.



Lithium Battery Discharge Characteristics:

When talking about lithium batteries it is useful to understand the difference between the peak and nominal voltage of the pack. The peak voltage is the voltage of the battery when fully charged, whilst the nominal voltage is the avegage operating voltage of the battery.



For example, a 36V Lithium Manganese (LiMn) battery is 42V when hot off the charger, whilst it will tend to operate around 36-38V for most of the discharge. A 48V Lithium Iron Phosphate (LiFePO4) can be as high as 60V at the end of charging but will normally operate around 48-52V whilst discharging.

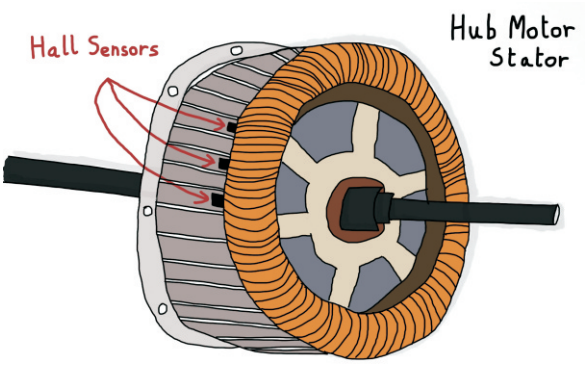
It should also be noted that the more you discharge a lithium battery at higher rates the shorter the total lifespan of the battery will tend to be even if you are discharging within the manufacturer's recommended discharge rating.

C Rating:

The C rating is a way to rate the battery's ability to discharge at particular currents, relative to its capacity. For example, if the battery's cells are rated for a 2C discharge, and the battery is a 10Ah battery, then the recommended maximum discharge rate is 2(C) x 10(Ah) which comes out to 20A. Discharges at current levels above the recommended C rating risk damaging the cells and reducing their total cycle life.

Motor/Motor Controller Terminology:

Hall Sensors:



In modern direct drive hub motors the current is supplied sequentially to the three different "phase" wires coming from the motor (normally visible as thick green, blue and yellow wires coming from the hub) to make the motor spin forwards correctly. However, when the motor is stationary the controller can have a hard time figuring out the order in which to supply the current. The hall sensor is a small chip inside the motor (there are typically 3 of them) which sends a signal to the motor controller to help it figure out the order. If a hall sensor is defective it can lead to the characteristic stuttery behaviour seen from the motor.

Sensored Vs Sensorless:

Now that we know what a hall sensor is, we know what it meant by a sensored controller: one which uses the hall sensors inside the motor to figure out how to power the motor. A sensorless controller does not have the extra help and this is why it can be a little stuttery at low speeds until the motor starts spinning fast enough to generate a voltage for the controller to interpret.

Shunt / Shunt Resistance:

In order to determine the amount of current (amps) flowing in a circuit something called a shunt resistor is normally used. In most motor controllers there is a small shunt resistor on the circuit board that we know the resistance of and by measuring the voltage drop over this piece of material we can determine the current flowing from the battery. This is why it's important to make sure you calibrate the Cycle Analyst to the controller you use as an incorrect value will cause the Cycle Analyst to misread the current that is flowing, and therefore provide an erroneous value for the amp-hours used from the battery.

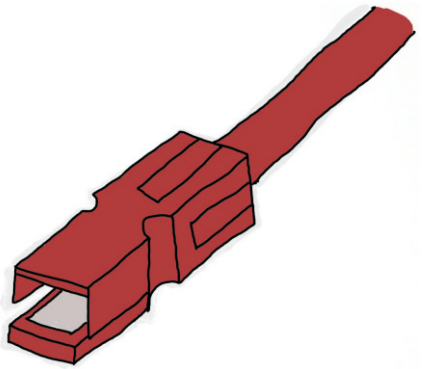
MOSFETs:

Inside the motor controller are a number of small electronic components called MOSFETs (an acronym for *metal-oxide-semiconductor field-effect transistor* but don't worry about that too much right now!). Put very simply, these MOSFETs inside the motor controller act as switches and turn on and off incredibly quickly to regulate the current the motor receives at any given time. In high power ebike applications you'll often hear of "blown MOSFETs" - this just means that the switching at high power levels became too stressful for the MOSFETs and they became damaged.

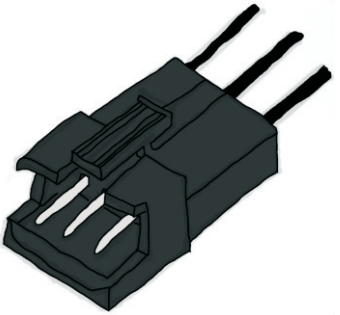
Miscellaneous:

Anderson Connectors:

Anderson connectors are normally found on wires that carry larger currents - such as those that supply the power from the motor controller to the motor and from the battery to the motor controller. They are gender-less - you just rotate them 180° if you need to connect them together.



JST-SM Series Connectors:



JST-SM Series connectors are for smaller wires carrying lower currents - such as those for the throttle connection and Cycle Analyst. They come in different sizes (number of pins in the housing) and have a male and female side.

Pedelec:

Pedelec stands for "pedal-electric" - it refers to bicycles that provide electrical assistance (via a motor) in response to the user's pedalling. A bicycle that is throttle controlled from the handlebars would therefore not qualify as a "pedelec" bicycle.

Multimeter:

A multimeter is a tool used for electrical measurements and diagnostics. It is one of those tools you'll never regret purchasing as it has many uses on an ebike for diagnostics and also beyond that for more general usage around the home. Most standard multimeters will have the ability to measure resistance in ohms (Ω), voltage in volts (V) and current in amps (A). Some also have a "diode" or "continuity" mode useful for testing for shorts. If an ebike stops working it is the go-to tool for figuring out why (and the Cycle Analyst can be a pretty handy tool as well!).