



The **E-Bike** Guide





Why You Want an E-Bike

Electric bicycles have the potential to make cycling for transportation accessible to the millions of people who find themselves, for whatever reason, not quite able to consider riding a regular bicycle. While a few purists and naysayers will claim that e-bikes aren't real bicycles, they do so from the position of being fortunate enough to have the fitness, the geography, the climate, and the lifestyle that permits everyday riding. But what of those with bad knees? Or those who live in a region so hilly and so sparsely populated that their morning commute would be akin to a daily Tour de France? What of the many who regularly transport children or cumbersome cargo throughout the day? Or those who live in hot, humid climates and can't pull off the "drenched in sweat" look at the office? Electric bicycles turn everyday biking into a viable transportation choice for those people as well, and in doing so offer an immediate and practical solution to our world's current over-reliance on automobiles.

Electric bicycles in cities provide an attractive option for both current automobile and transit users. By transforming auto and transit trips into e-bike trips, cities will see a healthier population, more transit capacity freed up, and less road congestion. Air quality will improve, and more communities will be able to experience the innumerable social and interpersonal benefits of active transportation.

But perhaps just as importantly, electric bicycles are really, incredibly fun. They can make riding for pure recreation once again viable for those who just don't have the fitness level to ride a normal pedal-only bike. There's a thing that happens when somebody gets on an e-bike for the first time and starts pedaling. As that pedal-assist kicks in and they find themselves being rapidly propelled forward by the combined effort of themselves and the machine, a wide grin plasters itself across their face. This is the "electric smile," and if the previous benefits of e-bikes didn't sell you on the technology, riding one certainly will.

Types of E-Bikes

E-bikes can be roughly grouped into two main types, based on the location of their motor. Hub motors are located in the wheel, replacing the regular hub, while mid-drive electric bicycles have the motor located on the frame.



HUB MOTOR E-BIKES | There are two different kinds of electric hub motors:

Direct drive hub motors are larger, and use the entire hub shell as the motor. They're faster and more durable, but have less torque. They're also heavier and have a bit of drag, resulting in less overall efficiency. These motors are always engaged and therefore can have regenerative braking, which will return some small amount of energy to the battery. As they have no moving parts, they're almost completely silent.

Geared hub motors are smaller and lighter than similarly powered direct drive motors, they could pass for a regular wheel hub. They tend to have greater torque, but have a lesser top speed than direct drive. They have a free-wheel, which means there is no resistance when the motor is not being used, but means you can't have regenerative braking. Geared hub motors also have moving parts, which means that when they are engaged there is a noticeably louder hum than an equivalent direct drive motor, and they may out a bit faster.

Hub motors can be located on either the front or rear wheel, each option having its own benefits and drawbacks. Front hub motors provide an "all wheel drive" sensation, with the rider's pedaling propelling the back wheel and the front wheel being "pulled" by the motor, a sensation which some riders appreciate and others dislike. Front hub motors are much easier to install and maintain as they don't interfere with the drivetrain or gearing, but have the tendency to spin out on occasion as there isn't much weight over the front of the bike.

Rear hub motors can handle higher power options, because the frame is better equipped to handle higher torque at the back than in the front, and can provide throttle, cadence, and/or torque sensor pedal assist, whereas front hubs generally can't offer torque sensor pedal assist. Rear hub motors are more cumbersome to install and maintain as they need to be worked around the drive-train, and tend to be quite back-heavy if the battery is also located towards the back of the bike, but are often preferred for offering a riding style more similar to a conventional bicycle.



MID DRIVE ELECTRIC BICYCLES | Mid drive systems mean the frame has been specifically designed to incorporate the motor on or next to the bottom bracket. This design has the advantage of using the standard drive-train of the bicycle, which allows it to use whatever gears are on the bicycle. In this system, if the rider changes the gears appropriately, the motor can turn closer to its ideal rotations per minute (RPM) whatever the speed of the bicycle, and be more efficient as a result. Conversely, hub motors cannot be geared to adjust their RPM as the bicycle speeds up, so they have a tendency to get "bogged down" on steep climbs. Mid-drive systems tend to feel more like a "normal bike," since they drive the pedals, just like your legs, and those who frequently climb long, steep hills tend to prefer mid-drive systems for their ability to handle long climbs. As they can leverage the bicycles lowest gears for climbs, mid drive systems can also leverage the high gears to

reach higher speeds on flat areas than a hub system.

Mid drives tend to have better weight distribution than hub motors since the motor is located at the cranks, creating a lower center of gravity and a more balanced ride as a result, especially if the battery is also mounted in the center of the bike.

Since the electric components of the bicycle are on the frame, mid drive bicycles make it easier to do simple repairs such as changing a flat, and are compatible with any wheel type. However, since they provide the power through the chain drive of the bicycle, they may see somewhat faster wear on those components than a hub drive e-bike that reduces the load on the chain drive. They also work best when the rider rides like a “normal bike,” utilizing the gears appropriately in order to keep the legs and motor working efficiently, a task some riders would prefer not to do.

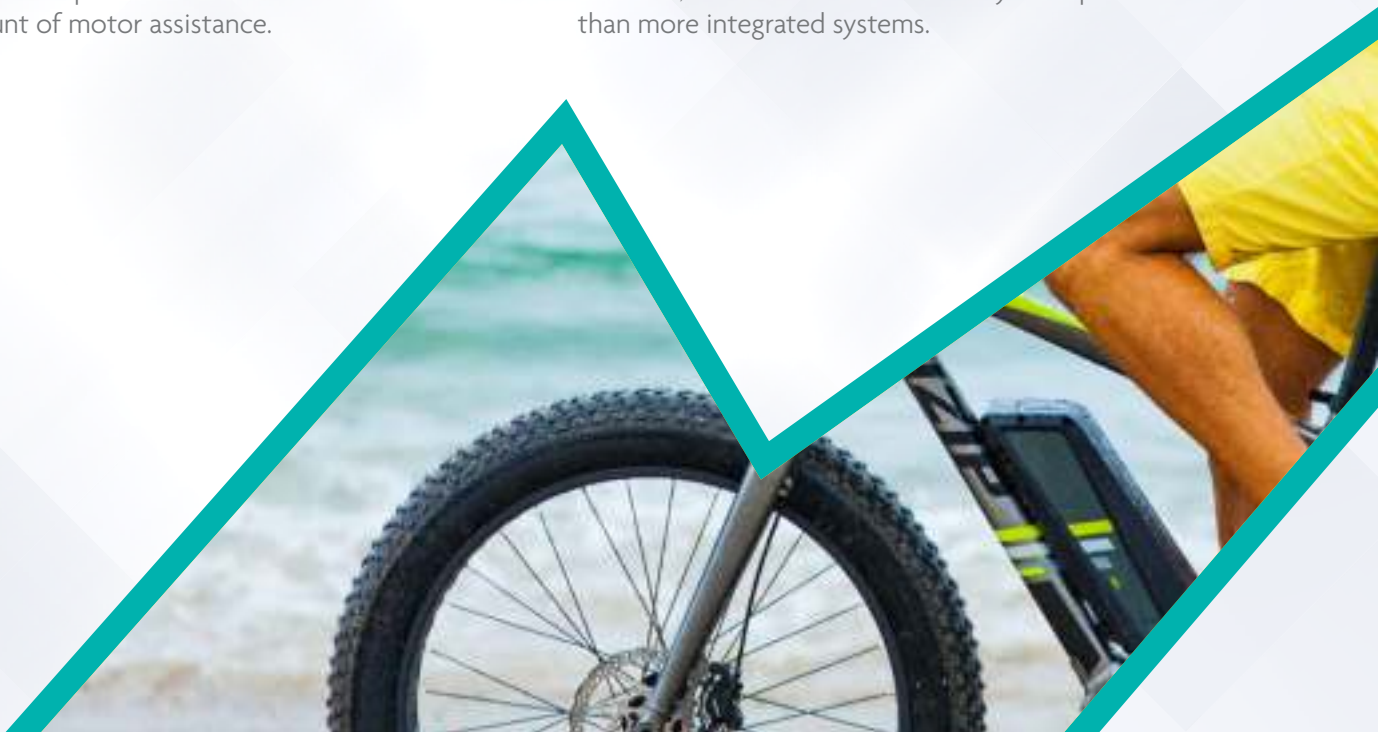
RETROFITTED E-BIKES | It can be a fairly simple process to retrofit an existing bicycle to electric assist. There are a number of after-market e-bike conversion kits available to turn almost any bicycle into an e-bike, depending on your needs and your budget. It should be noted that while this can be a simple process, the new generation of purpose-built e-bikes generally provide a much better user experience, higher degree of integration, and a better ride.

Hub motor conversion kits: The most common e-bike conversion kit uses a hub drive motor. Generally the process involves replacing either the front or back wheel with one that has a hub motor, then running the wiring to the motor controller and the battery, which is mounted on a back rack or in the place of a bottle cage. You can then choose whether you'd like a pedal sensor or a throttle to control the amount of motor assistance.

Mid drive conversion kits: There are also e-bike conversion kits for people who want mid-drive motors, which doesn't require the replacing of a wheel, but will require affixing a motor to a frame which was not designed to carry it, a transformation which is a little more difficult and isn't suitable for all types of bicycles. At present, there are many more e-bike conversion kits available in hub drive than mid drive, but availability of the latter is on the rise.

All-in-one wheel kits: The newest entrance into the market are all-in-one wheel motors, which house the motor, battery and controller into one hub or wheel. Companies like Super Pedestrian and FlyKly are pioneering this form of conversion kit, which only requires installing a new wheel and a small frame controller. These kits have the advantage of keeping the bike super clean looking – many people won't even realize it's an e-bike – and often come with smart-phone integration and bonus features such as auto-locking. However, as they're a very specific technology, maintenance will require sending the system back to the company rather than taking it to a bike shop. Though the products have been developed, the technology is still so new that it is not yet available for purchase. Something to keep an eye out for.

Friction drive: Lastly, and least common, are friction drive systems which involve a motor-controlled roller being installed onto the seat post above the back wheel. The roller sits on the wheel, and adds propulsion through friction with the wheel. These are simple systems which are easy to install and maintain, but are also considerably less powerful than more integrated systems.



Pedal Assist vs. Throttle Mode

PEDAL ASSIST



Beyond the different options for e-bike motors, there are also options for how you're going to get that motor to operate. All e-bikes operate either through throttle mode, pedal assist mode, or a combination of the two. Each has its own benefits and drawbacks, but understanding the options is important in finding the most suitable e-bike for you.

PEDAL ASSIST MODE, also referred to as pedelec, allows for the motor to be activated only through your pedalling. As you turn the cranks, the motor kicks in and offers more power to your ride, giving you an incredibly fun feeling of being much stronger than you actually are.

Almost all e-bikes with pedal-assist mode offer the ability to change the amount of power the motor will provide as you pedal, ranging from low-medium-high options all the way to more specific 1-10 options. The simplest form of pedal assistance is called the cadence sensor system, which applies only the amount of power you selected, no matter how hard you're pedalling. On more advanced e-bikes, you get cadence, wheel speed, and torque sensor systems, which sense how hard and fast you're pedalling and offer more assistance based on all 3 inputs. This is the most comprehensive way to provide motor power, and makes the bike feel

Many newer e-bikes offer **BOTH THROTTLE AND PEDAL ASSIST**, with the option to toggle back and forth between the modes, or with built-in mechanics that override the pedal assist mode as soon as you hit the throttle. While the pedal assist mode offers a fun, intuitive ride and a longer battery life, the option to also occasionally employ a little throttle can be very useful for when you need it.



THROTTLE MODE

like an extension of your legs. Basically, as you hit a hill, the motor will automatically kick in with a little more power to help you climb it. Torque sensor pedal assist systems result in a very intuitive feeling ride, and require you do little else other than pedal.

THROTTLE ASSIST MODE means the e-bike operates similar to a motorbike or scooter: when you hit the throttle, the motor activates. In this mode, you can pedal along with the motor, or you can simply hit the throttle, rest your weary legs, and cruise.

Throttles can take the form of a twist section on the handlebar, or a push button that you hit with your thumb. On most e-bikes, the power of the throttle can be controlled between low and full power depending on your needs.

The benefit of throttle mode is that you're able to activate the motor without pedaling, helpful in scenarios when you need a quick boost, such as getting started on a steep hill or carrying a particularly heavy load. However, since it doesn't employ your human-power, using throttle mode consistently will wear the battery out faster than pedal assist mode. E-bikes with throttle mode are also illegal in some regions, so it's important to check your local regulations before considering an e-bike with a throttle.

Power, Range, and Batteries

Manufacturers will often give estimates of the range for the model of electric bicycle they produce, but it is important to realize that there are many factors that affect the range you might experience. The weight of the rider, the amount of effort the rider puts into the pedaling, the hilliness of the terrain you will be riding in, how well inflated your tires are, and how much stuff are you carrying with you will all affect your e-bike's range. Even the exact same ride with the exact same rider on different days could have a different range because of variance in the wind. There is no standardized system for designating the estimated range of an e-bike like you might find in fuel efficiency reports for automobiles, but developing an understanding of the motor and the batteries will allow you to compare e-bikes with some insight on which one will take you further.

Motors are rated according to their power draw in Watts (W). Typically electric bicycles will have motors that will range from 250 Watts to up to 1200 Watts or more. The larger the motor the more energy (Watts) it will draw from the batteries and the more power it will deliver.

How to understand how far it will take you:

VOLTAGE (V): The measure of the potential power of the battery. A higher voltage battery will provide more power. Typical voltages for batteries are 24V, 36V and 48V.

AMP HOURS (AH): This is the measure of energy capacity of the battery measured in how many Amps the battery can deliver per hour. Typically this will range from 8 to 20 Ah.

WATT-HOURS (WH): Is the measure of the stored energy of the battery measured in Watt hours. It can be calculated by multiplying the Amp hours of the battery by the voltage ($Ah \times V = Wh$). For example a 36V battery with 11 amp hours would have 396 Amp hours.

Typically an electric bicycle will use somewhere between 8 and 16 Watt-hours per kilometer depending on how much the rider pedals and how many hills they are climbing. So if you took a battery's calculated Watt hours and divided it by your estimated Wh/km you will get a sense of how far you'll go:

For example if I have a battery that has 400 Wh and I'm in a very flat terrain so I think I'll use 8Wh/km, my range would be $400Wh \div 8Wh/km = 50km$ (31miles) before the battery loses all its energy.

For the same battery if I'm in a terrain with nothing but climbing hills I might estimate my energy usage to be 16Wh/km. My range for the same 400Wh battery would be $400Wh \div 16Wh/Km = 25km$ (15.5 miles) before the battery loses all its energy.

The reality of course is somewhere in between with a typical ride being a mix of terrain, human effort, wind, and weight of stuff being carried.

Manufacturers don't always publish all this information in their product brochures but if you can get the Voltage and Amp hours of the battery you'll be able to calculate the Watt-hours and figure out how far it can take you in different terrain and situations.

Most newer systems provide you with real-time range indicators, which factor in usage, and how much energy still resides in a battery and provides you with a miles-till-empty figure, which is continually updated. By managing your power usage, this means you never really need to worry about running out of juice mid-ride!

Batteries

Most e-bikes currently use lead-acid or Lithium-ion batteries, and a rapidly-disappearing few still use nickel based batteries. As a general rule, look for bikes which use Lithium-ion batteries.



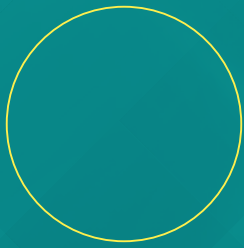
Lead acid batteries are the least expensive, and at present the most common type of e-bike battery worldwide. They have a short life cycle if used regularly in a deep discharge environment. They require more frequent charging, and are ultimately too heavy to remain practical for use in e-bikes.



Nickel-Cadmium (NiCad) and Nickel Metal Hydride (NiMH) batteries are much lighter and more efficient than lead based batteries, but due to the former's risk of soil contamination upon disposal in landfills, nickel based batteries are largely disappearing from use in e-bikes.



Lithium-ion batteries are the lightest, most effective and increasingly most common battery packs out there for e-bikes. They have a good energy density and will last through many charge cycles. Most newer e-bikes use 18650 Lithium Ion battery cells. These are very high quality, and are the same type of batteries that are used in most electric cars, including Tesla!



Which E-Bike is Right For Me?

There is an enormous range of options for e-bikes on the market, and the choices can understandably be overwhelming. Beyond the motor and mode options, there are also the more basic choices to be made about what kind of bike you want. E-bikes are now available in nearly all bike styles: folding bikes, cargo bikes, city bikes, fat bikes, mountain bikes, cruisers, you name it. Basically the only bike style which so far (and for good reason) hasn't been made electric is kids' bikes.

The best place to start is to determine which feature is most important to you: the motor, the range, the mode, or the style. There is no right answer in this decision, it's entirely up to your personal needs and tastes. If you're certain that you want to the fast-

est e-bike on the market, then you'll need to go for a high-watt mid-drive motor, but that may mean sacrificing having the stylish step-through frame with an integrated rear rack you had your eye on. If you know you'd like a lightweight folding e-bike, you'll have to sacrifice a bit power. If you want to ride long distances, then look for an e-bike with a battery of over 400 watt hours. Similarly, if you know you want both throttle and pedal assist, you'll have to see what's out there and then reanalyze your priorities from that jumping off point.

Deciding definitively on either one motor type, one mode, one range, or one bike style will help to narrow down your options and make the entire process less overwhelming.



What Makes a Good E-Bike?

There are two main elements to look at when considering an electric bicycle, the electric and the bicycle. While an e-bike's quality has much to do with the quality of its electronic components, it is still fundamentally a bicycle. A poor-quality bicycle with high-quality electronics won't do you much good in the long run, nor will a high-quality bicycle with poor-quality electronics.

A very good e-bike would ideally have all of the components that make a bicycle great: a durable frame, high-quality shifters, an effective braking system, strong wheels, a stable fork, and the list goes on. Add to that a battery that won't wear out quickly and an electronics system that delivers its promised power and range, with a life cycle of 5-10 years with regular servicing.

Look over the components – both electronic and mechanical – of the e-bike you're

considering and do your research on each of them. As e-bike technology improves, some companies are increasingly able to offer quality e-bikes at much lower price points than previously imaginable. However, the old adage is still true, you get what you pay for. If an e-bike seems unrealistically cheap, it probably is, and you can expect to run into more issues and discomfort with a very cheap bike than with a mid-range model.

Similarly to a regular bicycle, finding an e-bike that you like won't only be about the technology, but about the comfort of the bike itself. Do you like the riding posture? Does it feel evenly balanced? Are you able to pedal it without the motor on? While the specifications of the electronics are important, it's also important to remember that this is still a bicycle, and you have to feel comfortable riding it.



How to Buy an E-Bike

Just like buying a regular bicycle, buying an e-bike in a brick-and-mortar bike shop will always produce better results than buying online. Having knowledgeable staff on hand to answer your many questions will not only help you in your initial purchase, but will be invaluable going forward.

If the staff seem disinterested in speaking about e-bikes, look for a shop where e-bikes are a large part of the focus, rather just an afterthought. Talking to people who are committed to the e-bike movement will ensure you get what is best suited to your needs, not just what's easiest to sell you.

It's okay (nay, encouraged) to take time in making your decision. Just as you wouldn't wander into a car dealership and buy a sedan without knowing anything about it, you shouldn't feel pressured to make a decision on an e-bike the first day you walk into a shop. After all, e-bikes aren't toys, they're transportation.

Ask a lot of questions, test ride a lot of models, and don't be afraid to take a pamphlet home to do your

research before coming back to make a purchase.

A few things to keep in mind:

- **Electric bicycles aren't cheap.** You can expect to pay around \$1,500 for a quality e-bike with a lithium-ion battery and throttle or cadence sensor, and over \$2,500 for one with a torque sensor. Once you get into electric cargo bikes and specialized bikes, the figures are upwards of \$4,000.
- **As a rule,** a 1-year warranty on the motor, parts, and battery is the minimum you should expect from any e-bike manufacturer. Anything less should be a red flag, and for e-bikes over \$2,000 it's reasonable to expect a 2-year warranty.
- **Batteries are not designed to last forever.** While many manufacturers will advertise that their batteries last 1,000 full charge cycles (around 3 years of heavy use), the real figure is closer to the 600-800 range. Check to see if your battery is covered under separate warranty than the other parts, and speak with the shop to discuss their process for replacing batteries.



Things to Consider First

Now that you feel reasonably well-equipped to purchase an e-bike, there are a few things to keep in mind to make sure your new ride will fit comfortably into your lifestyle.

STORAGE | With a few notable exceptions, most e-bikes are heavy. They can weigh anywhere between 40-60 lbs, and as such aren't easily carried up stairs to an apartment. On the other end of the spectrum, they're expensive, so they aren't something you want to be leaving outside overnight. Consider where you're going to store your e-bike, and if it's reasonable to expect that you can get it in and out every day with minimal hassle. Batteries also don't like the cold, so ideally you would have a secure, convenient storage space with access to an outlet, that is kept warm.

ACCESSORIES | Once you have your bike, you might find that your enjoyment of it would be improved by adding a back rack and

getting a few panniers, or that the integrated lighting isn't quite sufficient for the dark country roads you ride. Since you're cruising around on an expensive piece of technology, you'll also need a very good lock. Factor the cost of accessories into your budget before making a purchase.

REGULATIONS | While e-bikes are legal in most places, they aren't completely legal everywhere and it's worth doing your due diligence. Some jurisdictions ban the use of throttle-controlled e-bikes, some ban e-bikes with motors over a certain wattage, while others file all e-bikes under the same categories as scooters and in doing so attach a whole whack of licensing requirements to them. Check your local laws to ensure that whatever e-bike you're considering purchasing is road legal and hassle free where you plan to ride it.