

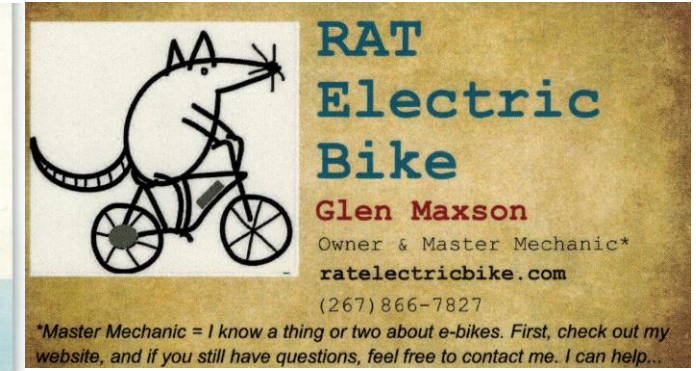
# All About Electric Bicycles!

[Glen Maxson](#)

Center for Learning in Retirement

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# Who Am I



- Penn State grad 1977
- Information Technology professional (1978-2011)
- Retired from Intel 2011
- Teach Tech - Del Val CLR and Temple OLLI (<http://seniortechadvisor.com/>)
- Build electric bikes as a hobby (<http://ratelectricbike.com/>)
- E-bike advocate (<https://doylestownpa.org/government/boards-and-commissions/bike-and-hike-committee/>) — meets 3<sup>rd</sup> Tuesday each month, which is today

# Contents

- Why consider an e-bike?
- What is an electric bicycle?
- E-bike Vocabulary
- Cadence vs Torque sensors
- E-bike power specs
- Battery tech
- E-bike laws
- Maintenance
- Build versus buy
- Build process
- Buy options
- Decision time

# Why consider an e-bike?



- **Benefits** of e-bikes for ‘seniors’ ([source](#))

- [Riding an electric bike for seniors is one of the best ways to stay active](#), improve cognitive function, and stimulate your mind
- Helps improve your **cardiovascular health** and lower blood pressure, while reducing stress on your joints and muscles
- Can be safer, and is certainly more **environmentally friendly**, than driving a car
- It’s a great way to **reduce stress** levels because it helps you get away from your everyday life for a little while
- Can help you **lose weight**
- Can enhance **social interaction** and gets you outside, enjoying nature and spending time with others...

Time for a short video (2:07min)



# What is an electric bicycle?

- An **electric bicycle** (**e-bike**, **eBike**, etc.) is a [motorized bicycle](#) with an integrated [electric motor](#) used to assist propulsion.
- E-bikes generally fall into two broad categories:
  - bikes that assist the rider's pedal-power (i.e. [pedelecs](#))
  - bikes that add a throttle

Note: e-bikes must have 'fully operable' bicycle pedals, and can have either pedal-assist or throttle, or both



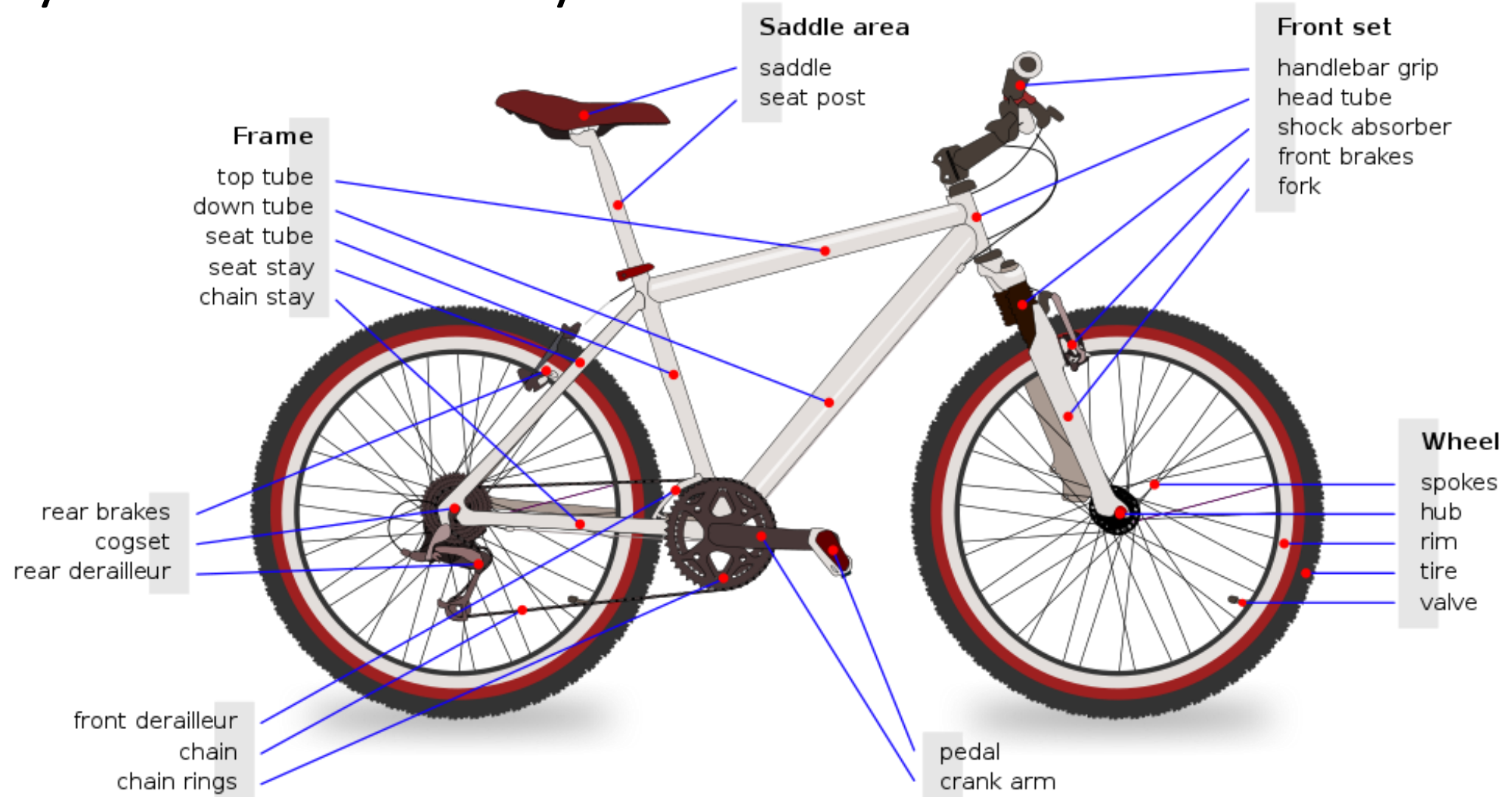
# Common locations for an electric motor on an e-bike

- [Rear hub](#)
- [Mid-drive](#)
- [Front hub](#)



- See also:
  - [Electric bike motors: everything you need to know](#)
  - [E-Bike Conversion Kit Buying Guide](#)

# Bicycle Vocabulary





# E-Bike Vocabulary

- **Hub motor** - an electric motor located in the front or rear hub
- **Mid-drive** - a motor located at the center of a bike, typically between the pedals
- **Battery** - energy storage that delivers a specific voltage and current to power an electric motor
- **Controller** - an electronic circuit that controls the speed of the electric motor
- **Display** - multifunction lcd display, used to access a variety of functions
- **Motor cutoff switch** - cuts off all power to the motor when a brake lever is squeezed
- **PAS** (Pedal Assist System) - the motor delivers additional power in proportion to the effort being exerted by the rider (incl. cadence vs. torque sensing\*)
- **Throttle** – located on the handlebar, allows the rider to engage motor power while pedaling or without pedaling

# E-Bike Vocabulary



# Torque Sensor vs. Cadence Sensor on Electric Bikes

- Your e-bike will likely be equipped with either one of two sensors: Cadence or Torque
  - These sensors communicate with your bike's pedal-assist system (PAS) to engage the motor and propel the bike forward
- A cadence-based pedal assist system engages the e-bike's motor when a rider begins to pedal
  - As the rider's pedaling speed (cadence) increases, the pedal-assist will reduce the motor's output (power contribution)
  - As a rider's pedaling speed decreases, PAS will increase the motor's output to propel the rider forward
- Think of cadence pedal assist as on-off switch.

# Torque Sensor vs. Cadence Sensor on Electric Bikes

- A torque sensor measures how much force a rider applies to the pedals, then determines how much power the motor should output to the e-bike
- Torque sensors make these adjustments in real-time, increasing or decreasing the motor's output in unison with the amount of pedal force a rider applies
  - The harder you pedal, the more output your motor will provide, up to the preset limit for a given PAS level.
  - The less intense you pedal, the motor will meet you where you're at and output less power.
- Torque pedal assist makes sense if you want an experience that's closer to pedaling a conventional bike

# Which e-bikes have torque sensing?

- Many lower-cost e-bikes feature cadence sensing pedal assist
  - This is usually the default if torque sensing isn't specified
- In the reasonably priced e-bike category, you'll find bikes like the
  - Aventon [Adventure.2](#) and [Level.2](#) both offer torque sensing





# E-bike power specs and what they mean

**Watt** - a unit of power (used to [quantify](#) the rate of [energy transfer](#))

**Watt Hour** - a unit of energy equivalent to one watt (1W) of power expended for one hour

**Volt** - the [electric potential](#) between two points of a [conducting wire](#)

**Amp** - the 'strength' of an electrical current

Or an ampere is an electrical current equivalent to  $10^{19}$  elementary charges passing every 1.602176634 seconds

**Amp Hour** - how many fixed number of Amps a battery can sustain for one hour

- factor Voltage and Amp Hours together to determine how far you might travel on a full charge\*

Calculate - Watts / Volts = Amps

E-bike motors are rated in Volts and Watts

- Bafang BBSHD 48v 1000w mid-drive motor

E-bike batteries are rated in Volts and Amp Hours

- Joyisi 48v 14.5ah battery

See also: [Understanding E-Bike Power, Range, And Energy](#)

Amp-Hours (**Ah**) x Voltage (**V**) = Watt-Hours (**Wh**)

$$14 \text{ Ah} \times 36 \text{ V} = 504 \text{ Wh}$$

**Approximate:**

1-mile requires 25 Wh

$$504 \text{ Wh} \times \frac{1\text{-mile}}{20 \text{ Wh}} = 25\text{-miles}$$



# So how far will you go on a single charge?

- It depends:
  - Using a real life example:
    - $14.5\text{ah} * 48\text{v} = 696\text{wh}$ , then  $696\text{wh} * (1/20) = 34.8\text{miles}$  (~**35 miles** on a 100% charge)
  - Caveat - As long as you use only the throttle, ride on a smooth, level surface with no wind at sea level and 82.4 degrees Fahrenheit, and weigh 170 pounds...
  - In reality, you'll be adding energy through pedaling, so I usually use 35 miles as a worse-case number and expect to get significantly more miles per charge – *I'm actually getting around 60 miles on a 100% charge on my 12.5ah battery! More on a 14.5ah battery I expect (I'm still figuring this out)...*

# Batteries

- Here's a good article concerning e-bike batteries:
  - [Everything you need to know about e-bike batteries \[from a battery engineer\]](#)
- And another:
  - [ELECTRIC BIKE BATTERIES EXPLAINED](#)
- And another, if you're curious how one increases voltage and/or amperage in a battery (basic DC electricity stuff):
  - [How To Connect Batteries in Series and Parallel](#)
- Let's talk about battery design, cell chemistry, and care and feeding(aka charging) your e-bike battery

# Battery Design

- E-bike battery packs are made up of individual battery “cells”
- The most common form-factor for an e-bike battery pack is the 18650, which is a cylindrical cell with a nominal voltage of 3.7 volts
- Look for cells from Panasonic, LG, and Samsung which have a good reputation for quality
- E-bike battery tech will change as tech for EVs improves



# 18650

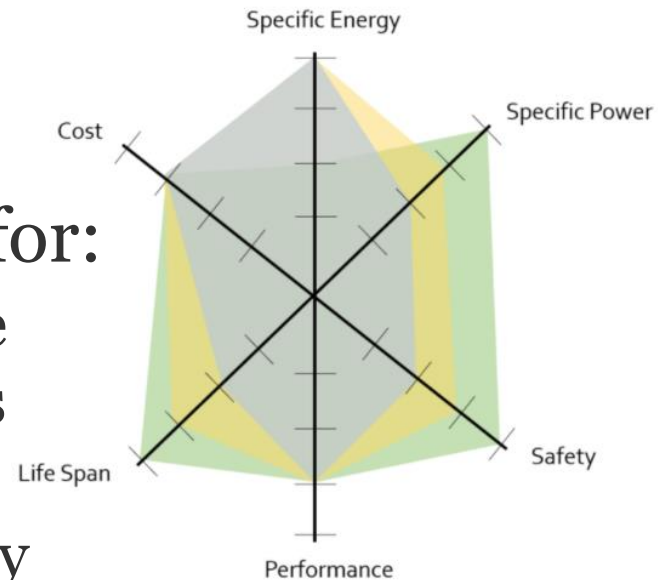
Refers to the diameter of the cylindrical cell in millimeters.

Identifier that the cell is a cylindrical cell

Refers to the height of the cylindrical cell in millimeters.

# Cell Chemistry

- Lithium-ion (li-ion) batteries are the best option for e-bikes today
- The most popular ones for e-bikes include:
  - Nickel Manganese Cobalt (NMC) – most common!
  - Lithium Cobalt Oxide (LCO)
  - Lithium Iron Phosphate (LFP/LiFePo<sub>4</sub>)
- When selecting a cell chemistry look for:
  - Specific Energy: has an impact on range
  - Specific Power: how the battery handles high load scenarios
  - Safety: does the chemistry have a history of [high in-field failures](#)? (this is bad!)



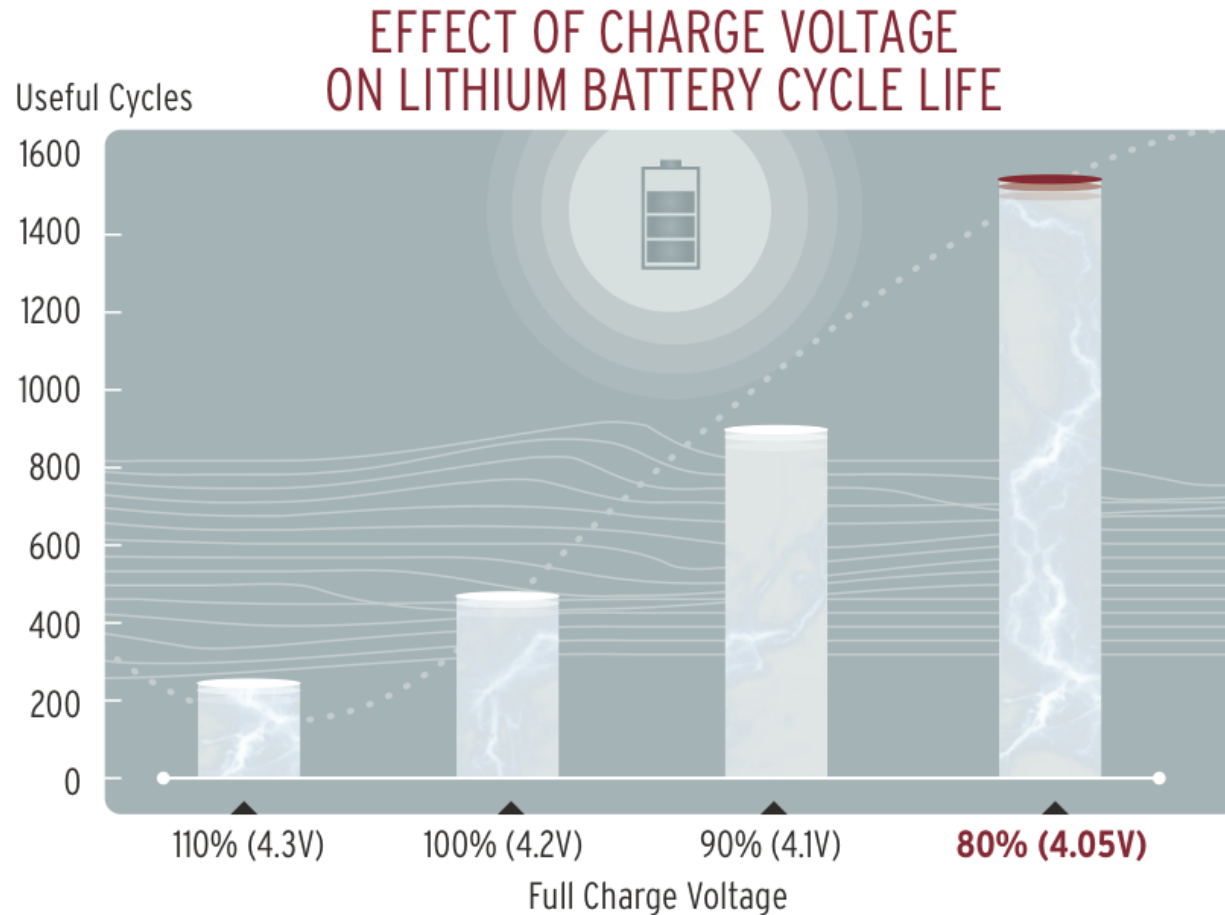
NMC  
LCO  
LFP



# Care and Feeding Your Battery

1. The thing that will kill your battery faster than anything else is leaving it fully charged at elevated temperatures. If it's 80 degrees outside and you have your e-bike battery fully charged, move it indoors where it's cooler and try to drain the battery as soon as possible.
  2. Charge your battery at room temperature as often as possible.
  3. When sourcing an e-bike battery charger, the slower the charge rate the better. For example, if you have a 2-Amp charger, and your battery is a 14 Ah battery pack, you are charging at  $14 \text{ Ah} / 2\text{-Amps} = 7\text{-hours}$ . This is a nice, slow charge which will improve the longevity of your battery. Avoid charging at rates that are faster than 2-hours for a full charge.
- **Bottomline:** Choose LFP or NMC chemistry, slow charge, avoid storing or charging at hotter temperatures, and leave the battery at around 30% charge if you don't plan on using it for a while.

# Effect of charge voltage on battery cycle life



**Note:** This applies to ALL Lithium-ion (li-ion) batteries in cell phones, laptops, e-bikes, and even your electric car!

# A word about battery chargers

- The charger you get when you buy a new e-bike or battery will charge your battery to 100% every time. This is not ideal!
- Consider getting one of these chargers from [Luna](#) instead:



or



Note: These chargers are designed for 48 volt batteries. If your battery is 36, 52, or 72 volts, there are different chargers available for those batteries [here](#).

# E-bike laws - Federal

- At the **federal level**, a 2002 law enacted by Congress, [HB 727](#), amended the Consumer Product Safety Commission definition of e-bikes. The law defined a low-speed electric bicycle as “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.” The federal law permits e-bikes to be powered by the motor alone (a “throttle-assist” e-bike), or by a combination of motor and human power (a “pedal-assist” e-bike).

# E-bike laws – Pennsylvania State

- At the **Pennsylvania state level** ([2014 Act 154](#)), “Pedalcycle with electric assist.” A vehicle weighing not more than 100 pounds with two or three wheels more than 11 inches in diameter, manufactured or assembled with an electric motor system rated at not more than 750 watts and equipped with operable pedals and capable of a speed not more than 20 miles per hour on a level surface when powered by the motor source only.
- In addition, e-bikes “do not require a certificate of inspection or insurance” and “are afforded ALL of the rights and responsibilities of other bicycles under [PA law](#)”.
- See also: [PENNSYLVANIA E-BIKE LAW](#) handout, and



# E-bike laws – Local



Hopefully our local community will adopt the [Model Electric Bicycle Law](#) from [PeopleForBike.org](#) because THIS does not work... Or adopt this [E-Bike Ordinance](#) recently drafted for review by the Doylestown Community [Bike and Hike Committee](#) (April 18, 2022)

# Maintenance

- Learn how to inspect and care for your e-bike
  - How to adjust your gear selector and brakes
  - Maintain correct tire pressure and know how to repair/change your tires
  - Monitor spoke tension, etc.
- Know what tools and spare parts you need to carry with you when you ride
- And know when to call the pros!



# E-Bike Rider's Backpack

- Identification and medical card
- Cash
- USB charging cable (for your phone)
- Water
- Granola bar
- Small medical kit (incl. mask & gloves)
- Allen wrench(es)
- Tire valve stem removal tool
- Slime (or FlatOut)
- Tire pump
- Not shown
  - Cell phone (never leave home without it)



# Repair Kit (always on the bike)

- Spare tube
- Tire pump
- Tire levers
- Bicycle multi-tool (like this one)
  - [Crankbrothers M19 Multi-Tool](#) w/ Case

You can keep this kit light since most of your gear will already be in your backpack, including layers for extended rides.



# E-Bike - Build versus Buy decision

- The 'build' option is for the tinkerer who has some technical skills and 'shop' space necessary to do the job and have a safe e-bike in the end
- Building an e-bike will most likely save a considerable amount of money over a commercial e-bike with similar components
- Buying a pre-built e-bike is complicated by the fact that there are many choices and you need to know something about the technology to make an educated purchase decision (hence why you're here)
- Regardless of whether you build or buy, this IS a bicycle and you'll need to maintain it. Educate yourself about your e-bike so you know what to watch for, how to make basic repairs, and when to visit your local shop



# The DIY Conundrum

- What if you build a 48v 1000w throttle-only e-bike without pedal assist? Where do you fall under federal and Pennsylvania law, and should you care?
- The answers are:
  - you don't, and
  - yes (you should care)
- The law is clear and you'll likely be operating somewhere outside your legal protections

# Build process

**So, you think you want to build an e-bike and save a bunch of money?**

- It's doable IF you have some technical skills AND patience (and tools)
- Steps for an e-bike builder:
  1. Find a 'donor' bike
  2. Inventory reusable parts
  3. Purchase replacement parts and necessary tools to complete your build
  4. Order the motor, battery, display, and any essential cables and/or adapters
  5. Watch a bunch of 'how-to' YouTube videos
  6. Start building (repeat steps 3-5 as needed)
  7. Test, tweak, and have fun...

# E-bike builds #1 and #5

48v 1000w Voilamart gearless rear hub - TREK frame (hard tail)



48v 500w Bafang geared rear hub - TREK frame (full-suspension)



# E-bike builds #3 and #6

48v 1000w Bafang mid-drive  
- Gary Fisher frame (hard tail)



48v 1000w Bafang geared rear hub  
- (Costco) Northrock XC00 'fat-tire'





# E-Bike - Build versus Buy

- There is another option:  
Ask someone else build an e-bike for you – introducing [JohnnyNerdOut](#)
- John can take your existing bike and customize it with a battery, motor, and display to help you accomplish your e-biking goals, all for \$350 plus the cost of parts and shipping...



# Ex. Johnny's Norco Scene build vs. production

- Johnny built a pair of mid-drive [Norco Scene custom e-bikes](#) for his in-laws  
Cost ~\$2100 each + tax versus the factory [Norco Scene VLT](#) e-bike for \$2699





# And another DIY e-bike builder I discovered

- Introducing [Matt Robertson](#)
  - Check out his blog post [“How To Build An Ebike From Scratch”](#)
  - Matt has installed a mid-drive (BBSHD) motor on a ‘full-suspension’ bike frame (which I didn’t know could be done)
  - If you’re thinking about building your own e-bike, definitely check Matt’s blog before starting – I wish I had!

\*



m@Robertson

April 27, 2022

General Bike Stuff, General Ebike, Rants

*Introduction (you are here)*

*Step 1: [Planning](#)*

*Step 2: [Hunting](#)*

*Step 3: [Tinkering](#)*

*Step 4: [Buying](#)*

*Step 5: [Assembling](#)*

*[Build Day 1](#)*

*[Build Day 2](#)*

*[Build Day 3](#)*

*Step 6: [Perfecting](#)*

*[Tools List](#)*

# Buy options ([source](#))

- The 'long' list: [List of Ebike Manufacturers and Brands](#)

Available Locally

## Aventon Pace 500.2 Next-Gen, \$1399 Step-Through



The Pace 500 is a class 3 bike (up to 28 mph with pedal assist) by virtue of its 500 W motor. It comes in two frame sizes, S/M and M/L, and two color choices, ghost white and celeste.

## Aventon Adventure.2, \$1899



The Adventure is a powerful (750 W motor) and versatile fat-tire eBike. It's a Class II eBike a high capacity battery and powerful rear hub motor. The Adventure has a medium step through frame in three sizes, small, medium, and large and comes in three colors, social sand, camouflage green and fire black.

## Bintelli Trend, \$1899



The Trend comes with many standard features, such as a 12.5AH lithium ion battery, an LCD display, and a powerful 500 watt motor that is capable of reaching speeds up to 20mph. For commuter needs Bintelli added in a rear rack and front suspension.



# Magnum Metro 750, \$2599



The Magnum Metro 750 is a beautifully designed, purpose built electric bike well suited to urban riding or commuting. Step-thru frame for easy mounting and dismounting. Powerful 750 watt motor paired with a large 48 volt 20 amp hour battery pack, offers both pedal assist and throttle mode.

## Gazelle Medeo T10 HMB, \$3299



This stylish and sporty electric bike has a dual battery capability to extend your ride beyond previous possibilities. It has a Bosch Performance Line Speed motor (65N) with an integrated 500W battery and 4 piston hydraulic brakes. The frame is a stable lightweight aluminum sloping frame available either as a low or high-step and comes in three sizes (45, 50 and 55 cm) and three colors (dust, ivory and jeans).

## Gazelle Ultimate C8 HMB, \$3395



This bike comes with a Bosch Performance Line motor with 50 N of torque and a 500 W integrated battery. It has high-grade Shimano disc brakes for optimal braking performance. The stable aluminum frame comes as a low-step model in three sizes (46, 53 and 57 cm) and two colors (petrol and sienna light). It has a durable, low maintenance Nexus 8 hub and Gates belt drive. The relaxed posture is due to upright handlebars and frame design.

Available Online

# E-Bikes to Consider Buying – recommended!

- Fair Price – great specs
  - [RadCity 5 Plus Electric Commuter Bike](#)
  - \$1,999 incl. free shipping





# E-Bikes to Consider Buying – recommended!

- Fair price - great specs, step-thru
  - [RadCity 5 Plus Step-Thru](#)
  - \$1,999 (incl. free shipping)





# E-Bikes to Consider Buying

- Lowest Price
  - [Ride1Up Core-5 XR](#)
  - \$1,045 includes free shipping



# Decision time

- Build or buy?
- Top bar or step thru?
- Mid-drive or rear hub?
- Power and range – battery removable or not?
- Design – handlebar and seat position?
- Weight – how much is too much?
- Cost – ditto?
- Company reputation and warranty – return policy?
- Maintenance and support – buy locally or mail order?
- Color (really?) – this will matter to some (for me, it must be red!)

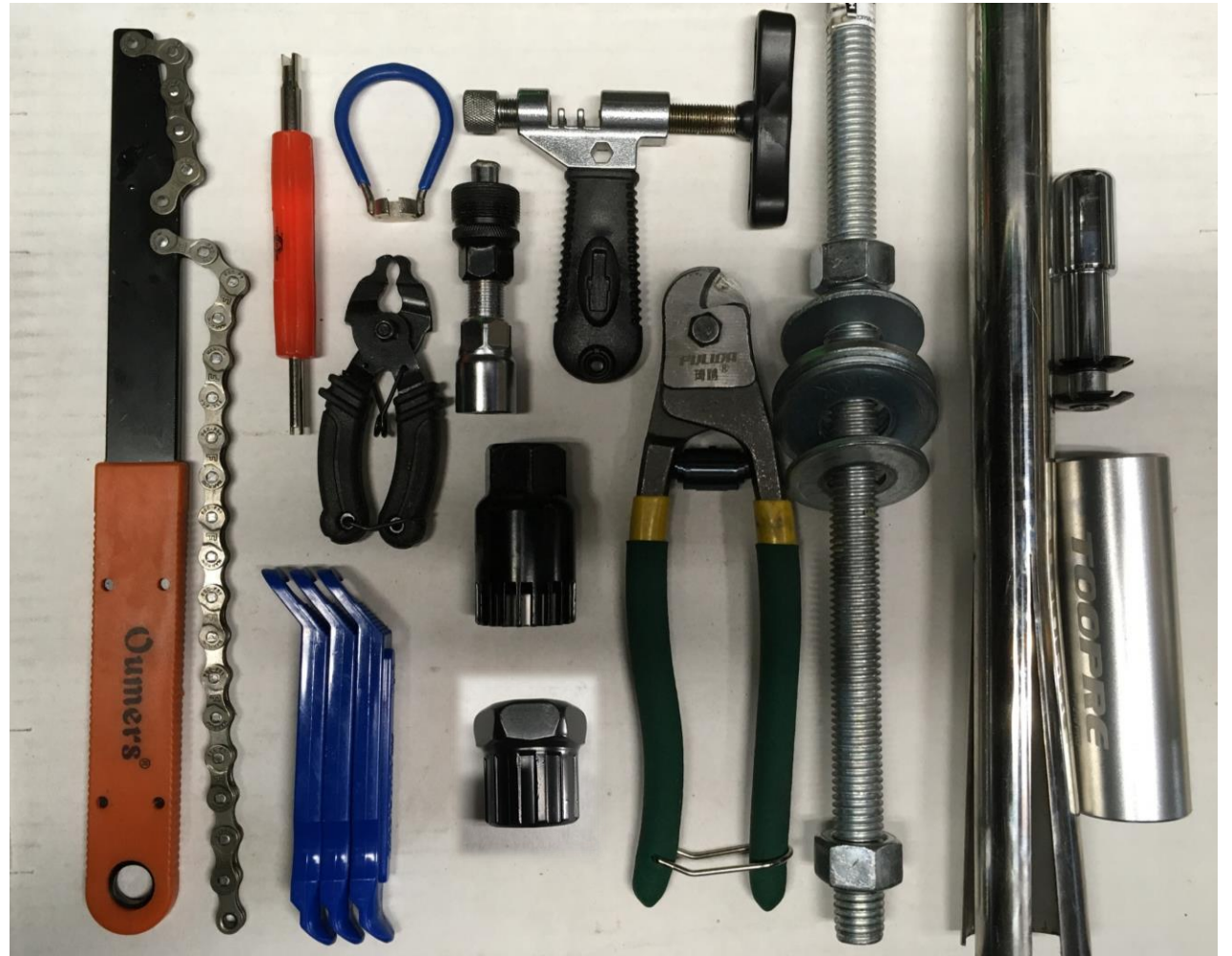
# A word about e-bike racks

- Traditional bicycle racks usually will not support the weight of your e-bike(s), so prepare to spend a bit more on a rack that does
- There are options: [Bicycle Racks \(for e-bikes\)](#)
  - But this rack from [Hollywood Racks](#) is the one I would buy
  - It's the Destination E Bike Rack for Electric Bikes (SKU: HR4500) for \$700
  - Here's a great video from Kyle at Area 13 about this rack
    - [Hollywood Destination Ebike Rack has a Ramp!](#)
  - And another [Destination E-Bike Rack Review](#)



# The E-Bike Builder's Toolkit (1 of 2)

- Freewheel turner (chain whip)
- Tire valve stem extractor (Schrader)
- Spoke adjuster tool
- 3 tire levers
- Chain master link pliers
- Crank arm extractor
- Adjustable chain rivet extractor
- Cartridge bottom bracket tool
- Cassette lockring tool
- Cable cutter
- Bike fork headset press (DIY version)
- Headset cup removal tool
- Fork star nut setting tool (and star)





# The E-Bike Builder's Toolkit (2 of 2)

- Bafang mid-drive motor installation tool
- Hex key wrenches
- Open end wrenches
- Crescent wrench (large)
- Phillips screw driver
- Loctite (blue)
- T-9 bicycle lube
- Tire valve adapter (helps to inflate air shocks)
- FlatOut or Slime (for flat protection)

