

personal electric vehicles

GET MORE PERSONAL

by Ted Dillard

When the term was coined, “personal electric vehicle” (PEV) meant almost exclusively electric cars. A decade later, we’re seeing the resurrection of the electric car—almost every major automobile manufacturer has something in development. With the electric car movement behind them, a parade of PEVs—from something you can sling over your shoulder to a 100 mph-plus electric racing motorcycle—is coming down the pike.

The price range for these vehicles is almost as extreme as the vehicles themselves. A few hundred dollars will buy you an around-town scooter. A whole lot more will get you a custom-built, full-on race motorcycle.

Even a year ago, many of these products were pipe dreams—pretty online prototypes, but not in actual production. Today, there are products that are available, affordable, and sitting on a showroom floor for you to see, touch, and ride.

Stand-up Scooters

We’ll start the tour with two extremes in the stand-up scooter market: Segway’s Personal Transporter and one of the ubiquitous Razor-type scooters. Both of these can be used for just about the same thing—getting around the city.

At a retail price of about \$8,000, the Segway is a premium product, commonly in use by police and security details. It weighs a little more than 100 pounds, and has a top speed of about 12.5 mph with a maximum range of 24 miles. A marvel of gyro-servo robotic technology, the Segway is controlled by the rider’s shifting weight.

SEGWAY X2



Courtesy Segway



Courtesy Razor

RAZOR ECOSMART METRO

Courtesy E-Glide



E-GLIDE 48

ULTRA MOTOR A2B



Courtesy Ultra Motor



Courtesy Crystalyte

CRYSTALYTE

On the other end of the scale is the simple, light, and inexpensive electric Razor scooters. Originally a kid's toy, Razor now offers the EcoSmart Metro, with larger wheels and more power, which means some propulsion oomph. At about \$400, with an 18 mph top end and a range of 15 miles, these scooters can get you everywhere a Segway can, plus you can carry it up the stairs and park it in your office.

A little more exciting is the E-Glide GI Powerboard. This 1,000-watt, 36-volt electric skateboard is not for the meek. At \$1,400, with a handheld controller and an estimated top speed of 24 mph, this is an affordable option for the commuter/adrenaline junkie.

Electric Bicycles

The electric bicycle market ranges from DIY kits for converting your standard bike with hub motors for bike wheels to purpose-built electric bicycles. There are several DIY kits, including Crystalyte and Golden Motor that come as individual parts or as complete packages with batteries and controllers. You can get an idea of acceleration by the motor's power rating, and electric bikes generally fall within the low 250 to 800 W range. Higher wattage gives you more speed and acceleration.

The Ultra Motor A2B is one of the more striking purpose-built bikes available. It weighs 72 pounds, can pull you (unassisted) at 20 mph, and has a range of about 20 miles (unassisted). The electric components are completely integrated and the bike includes disc brakes and tires that look more intended for a light motorcycle than a bicycle. These, as well as the kits, have pedals and even multispeed shifting, just as a standard bike. At \$2,700, they're not out of the range of what many die-hard bikers would pay for a racing bike.



Courtesy Trek

TREK RIDE+

Two mainstream bicycle manufacturers also have entries in the electric bike market—Trek and Schwinn both have electric models in the \$2,000 to \$3,000 range. Typically billed as “electric assist,” these bikes are aimed at the bicycle enthusiast who, for one reason or another, needs some help with the pedaling. At 250 to 350 W, these are at the lower end of the power spectrum, but are lighter and look and feel more like a standard bicycle. These bikes are very popular with people who want to get outside, ride with younger friends, or like bike touring and sightseeing—but have trouble staying out too long, going too far, climbing hills, or keeping up with the group.

Mopeds

Somewhere in the mix between electric bicycles and scooters is the “electric moped,” the most popular product sold in some stores, according to Harlan Flagg of Hollywood Electrics. Their Bumble Bee offers speeds of up to 20 mph,

BUMBLE BEE



Courtesy Bumble Bee



Courtesy Schwinn

SCHWINN SEARCHER E8

power ratings of about 800 W, and a range of 25 to 30 miles. At \$1,195, they are an attractive option for urban commuters. In most states, mopeds do not require a driver’s license or motor vehicle registration, an added bonus.

Riding an electric bicycle, whether electric-assist or high-powered moped, gives an interesting sensation from the electric motor. When pedaling one of the lower-powered bicycles you can, at will, simply turn up the power and you get the impression of being pulled forward, as if by some invisible force. With higher-powered bikes, the vehicle itself is heavier and pedaling becomes less feasible. Some of the bigger mopeds/scooters can’t be comfortably pedaled, and have pedals more as legal vestiges than for practical purposes.

Motor Scooters

The design of a motor scooter is great for an electric powertrain—smaller, fatter tires and wheels provide a good fit for the integrated hub motors (motors that are built into the wheels). A low deck doubles as a great place to put batteries. There’s plenty of room, the weight of the batteries is kept low, and the result is stability. As a result, there’s a huge array of very affordable electric scooters available—they are a common sight in Asian markets, and catching on in Europe and the United States.

One of the more popular brands is the Native Scooter from Electric Motorsport in Oakland, California, assembled from parts manufactured largely in Thailand. The Native Z1.5 has a 40-mile range, a 30 mph top speed, and sells for about \$2,200. The larger Z6(Li) increases the top speed to 60 mph and retails for \$4,800.

Some U.S. manufacturers are entering the market, with products available now or by order. Massachusetts-based Vectrix offers a small, lower-priced scooter, the VX-2, but also has the VX-1 Li—a near-motorcycle level machine with lithium battery technology and performance to match. The VX-1 Li has a top speed of 68 mph, a range of 40 to 60 miles,



Courtesy Vectrix

VECTRIX VX-1

and a 0-to-50 mph acceleration of 6 seconds, you're looking at a product that starts to blur the lines between a scooter and a motorcycle. At \$14,000 for the premium Li version, you clearly are paying the price for the performance you're getting.

Another new U.S.-based company is Current Motor Company, with three models ranging from \$6,500 (30-mile range and a 55 mph top speed) to \$8,000 (50-mile range and 65 mph top speed).

These scooters are a much tougher sell in the U.S. market than in Europe and Asia because of road systems and rider habits. They are marginally "highway capable," but even at a 70 mph top end, they won't give you a margin of speed and feeling of security on an interstate. Where posted speeds

ELECTRO MOTORSPORT NATIVE Z1500



Courtesy Electric Motorsport



Courtesy Current Motor Company

CURRENT MOTOR CO. DELUXE

are lower and roads are narrower, they're a great fit, and a workable solution for more rural, village, or country errand-running and commuting. The high cost makes them much less attractive in the city, though, where the acceleration and top speed aren't going to be as usable.

Whether you're jumping on for a grocery store run, using it to commute to work, or taking a sightseeing tour of local attractions, riding these scooters is as effortless as strapping on your shorty helmet and turning the key. Once you've

Two-Wheeled Rides

What are these PEVs like to ride? They all have a few things in common. First, they're virtually silent. Scooting around on the street or sidewalk takes a little patience and defensive driving where pedestrians, and even cars, are concerned. People aren't going to hear you, and they may see you, but it may take a few moments for them to really understand that what they're seeing is a person moving along at a fairly good clip, but not riding a bicycle.

Second, they're also clean—they don't have all the grease and oil that their gas-powered counterparts have. Plus, they have no tailpipe emissions. And if you recharge them with renewable energy, they're an all-around green transportation option.

The power from the electric motors is also very different—even the small scooters have a great deal of acceleration from a dead stop. They spin up without the use of a transmission, so there's no shifting needed—you just get smooth power.

Solar-Charging an EV



Courtesy Brammo

Since one of the reasons you invested in an EV or PEV was to give fossil fuels the boot, the last thing you'll want is to continue powering it with dirty fossil fuel and nuclear-made electricity—common grid sources in nearly all parts of the United States. How about a PV system to charge your EV or PEV?

The type and size of PV system that can provide charging for a PEV or EV varies widely. Typically, a PV system for PEV charging is much smaller than one designed to serve an EV's needs. You'll need to consider battery capacity and your daily commute, among other things, to arrive at a system to meet your PEV or EV needs. For example, a Razor scooter will be running 36 V with maybe 20 Ah, requiring about 720 Wh. A Native scooter may have 48 V with 40 to 60 Ah (1,920-2,880 Wh), and the Roehr runs at 7.7 kWh. If you figure the estimated ranges of the bikes based on the manufacturers' numbers, compared with the U.S. average daily commute of 16 miles, and consider battery capacity, you can design and size your system accordingly.

depleted the battery, you simply plug it into a standard 120 VAC outlet to recharge. Most of these products will typically come to a full charge within a 4 to 5 hours. There's no gas or oil; nothing to mix, drip, or smell; and the ride is silent. Riding around a campground in Maine in the wee morning hours, I've sneaked up on more than a few deer and other critters—a birdwatcher's dream. Stopped at a traffic light, you're aware of wind rustling in the trees, chirping crickets, and even conversations in neighboring cars.

Motorcycles

Electric motorcycles range from small, light, off-road dirt bikes like the Swiss-made Quantya, U.S.-made Zero, and the 6-speed transmission-equipped Brammo (also U.S.), up to "superbikes" like the Mission R, the Motoczysz E1pc, and the Roehr eSuperSport.

In the middle of this field are light street/commuter bikes like the Brammo Enertia and the Zero XU. Both companies are struggling to meet the challenges of offering production, consumer-ready Department of Transportation-approved products—looking like a business-school study of what faces a start-up company.

Both Brammo and Zero struggle with finding workable distribution. Brammo has tried to work outside the typical motorsports industry, originally offering their bikes through a national electronics retailer, on the premise that the bike fits into the "consumer electronics" market. Now, Brammo is looking to sign up independent dealers. Zero, currently able to deliver bikes, uses a combination of independent sales reps and a conventional dealer network. If you want to see a Zero, you may be able to go to a dealer or you may get a personal visit from your area rep, depending on where you live.

There are two basic issues with the standard motorsports-dealer model. First, the cost—a range of \$7,000 for smaller bikes to more than \$20,000 for some of the production superbikes. The ideology behind an electric motorcycle makes

QUANTYA EVO1



Courtesy Quantya

Full-size electric cars, with their higher-voltage, higher-capacity battery banks, will require much larger PV systems for charging. Typically, they'll need a system that can provide about 12 kWh of daily charging energy.

EV owners might think about putting in a simple PV array to directly charge the EV batteries, since PV-direct applications can be the most efficient and least costly of all system types. But that kind of system would charge the vehicle only when the sun is shining—requiring you to drive only early and late in the day, and not being anywhere but at home during solar-charging hours—and the system may have to be oversized to deal with decreased sun-hours in winter and cloudy weather.

Another option for a dedicated EV solar-charging system might be a PV system with a stand-alone inverter and a battery bank. A battery bank would allow you to charge the EV at times other than when the sun is shining. However, the size of the battery bank depends on the EV's charging requirements—with electric cars requiring a large battery bank, that could become a very expensive proposition. Off-grid, battery-based systems for smaller PEVs can be more economical.

With a batteryless grid-tied system, you can use the grid as a battery substitute. You can pump your PV-made energy into it year-round, and “draw” it out again whenever you need it: night or day, cloudy or sunny. Eliminating the batteries and other battery-related equipment

removes substantial system cost, as does not needing to size a PV array to provide enough energy even on poor solar days.

A grid-tied system is even more attractive for its design flexibility. You can spend what you can afford, and expand your system later on. On the other hand, if you oversize the grid-tied PV system, you can also offset some of your household use in addition to the EV use. Or do what Kevin Johnson and Lisa Brown did with their oversized solar EV charging system, and get an electric yard tractor (see “Solar Electricity: At Home...and on the Road” in *HP117*).

Beyond the home, solar charging stations are under development across the nation. SolarCity, in cooperation with Tesla Motors, has planned a “solar corridor,” allowing all-electric cars to charge at four locations between San Francisco and Los Angeles using solar energy. At the University of Central Florida, a PV-powered carport provides energy to charge electric vehicles by plugging them into an electrical outlet at the station. And in Plainville, Connecticut, General Electric's EV Solar Carport produces enough solar energy to charge about 13 cars per day through six charging stations, as well as power the location's overhead lighting. In addition to providing power or cars, the carport is also connected to the electrical grid, allowing it to send solar surplus power to the grid. Of course, to take advantage of these solar-charging opportunities, your daily commute destination will need to be close to a charging station.

—Michael Welch

Courtesy Motoczysz



MOTOCZYSZ

it a tough sell sitting on a sales floor next to a significantly cheaper gasoline-powered motorcycle. Second, dealers look to make money on after-sale service, and there's very little service required on an electric bike. No tune-ups; no oil changes. In some cases, the electronics on electric bikes can be serviced and updated with downloads from a website, and installed by the owner with a standard USB memory stick.

Although a few models in each line are squarely aimed at the commuter and a lot of the language on the sites is

BRAMMO ENERTIA



Courtesy Brammo

all about the green aspect of the bikes, they're really part of the enthusiast market. Even commuter bikes like the Enertia and the Zero S are designed to be fun to ride, handle well, and give you a little thrill, but when you look at the dirt bikes that Quanta, Zero, and Brammo offer, and then the street/sport bikes that Mission, Roehr, Mavizen, and Brammo have, you're looking at much more than just practical or environmentally responsible. A few of the dirt bikes have innovations like removable battery packs so you can show up at the pit with a few packs in the truck, run them hard, and switch them out—all without having to carry the extra weight on the bike. Some of the superbikes are barely street-legal replicas of all-out race bikes.

Riding the Zero and the Brammo provide different experiences. The Zero S is a more standard, lightweight sport-bike configuration, with the footpegs directly under the rider's center of gravity, allowing more control under fast or bumpy riding conditions.

The Brammo/cruiser/scooter position is more like sitting in a chair, while the Zero/sport position is more like riding a horse. Both bikes are nimble and quick, but the Brammo seems aimed at a more consumer-based crowd and new riders, while the Zero is pointed at the enthusiast market.

At the other extreme is Roehr's eSuperSport, a motorcycle that, for \$18,000, measures up to most gas-powered supersport bikes. Its lithium batteries are capable of a 75-mile range and the top speed is more than 100 mph. It has all of the features sport riders expect from a new model: 41 mm inverted, adjustable rebound and compression-dampening front forks; single shock with rising rate linkage rear suspension with



Courtesy Roehr

ROEHR ESUPERSPORT

adjustable preload; and double 300 mm disc, four-piston caliper front brakes and single-disc, two-piston caliper rear brakes; all in an oval-tube steel-beam frame.

The electric specs are equally impressive: a 50 kW (67 hp) peak AC induction motor that pumps out 80 foot-pounds of torque, with 7.7 kWh of lithium-iron phosphate high-discharge batteries, running at 96 V/80 Ah and 650 amps (peak). It's a bike you could take to the track. After riding a bike like this, you'll have no doubt you're living in the twenty-first century.

The "rider triangle," showing the relationships of the rider's seat, hand, and foot positions. The Zero shows a more forward position, with the rider's center of gravity squarely over the feet, allowing greater control. The Brammo shows a weight-back position, allowing more comfort, but less ability to shift weight to the footpegs.



Courtesy Zero



Courtesy Brammo

PEVs Compared

PEV	Weight (Lbs.)	Range (Miles)	Top Speed (mph)	Acceleration	Price	Comments
Razor EcoSmart Metro	75	15	18	Low*	\$400	Kid's toy for grown-up commuters
Bumble Bee	n/a	25	20	Low*	1,195	Electric moped
E-Glide GI Powerboard	57	10	24	High*	1,400	Extreme sports PEV
Native Z1.5	n/a	40	30	Moderate*	2,200	U.S. assembled
Schwinn Searcher E8	40	20	20	Low*	2,679	Standard bike design, incorporated drivetrain
Trek Fx+	45	20	20	Low*	2,679	Standard bike design, incorporated drivetrain
Ultra Motor A2B	72	20	20	Low*	2,700	Futuristic purpose-built design
Native Z6 (Li)	n/a	40	60	High*	4,800	U.S. assembled
Current Motors Deluxe	425	50	65	not published	8,000	U.S. assembled
Segway i2	100	24	12.5	Low*	8,000	High-tech gyro direction & speed control
Zero XU	218	30	50	5 sec. (0-60)	8,000	Commuter/sport
Brammo Enertia+	324	80	60	not published	9,000	Commuter/first-time rider
Quantya EV01 Strada	195	25	45	not published	11,000	Off-road/sport-derived design
Brammo Empulse 10.0	420	100	100	not published	14,000	Purpose-built chassis from U.S.
Vectrix VX-1 Li	425	60	68	6 sec. (0-50)	14,000	U.S./European manufacture
Roehr eSuperSport	470	75	100	4.2 sec. (0-60)	18,000	Based on Hyosung Motors U.S.A GT650R chassis

*Estimated from watt/weight specs

All specifications are as per the manufacturer's claims or, where absent, estimates based on the best available information. *Home Power* magazine accepts no liability for errors or omissions.



Courtesy Quantya

**QUANTYA EV01
STRADA**



With 141 hp and 115 foot-pounds of torque, the MissionEVT powertrain, with its liquid-cooled AC induction motor, is capable of 0 to 160 mph in one gear.

Courtesy Mission

For anyone who's been at a dirt track and heard the "angry horde of bees" din, the simple mechanical sound of the shocks and chain, along with a quiet whirl of the motor, is a little disarming. It is, however, one of the attractive things for riders who live and ride in populated areas—the ability to go for a hard ride without raising the neighbors' ire.

The street bike ride is like nothing you've ever experienced. An electric bike with a 350 W motor is one thing, but a motorcycle with a 10 kW or greater motor is something else entirely. Electric motors give 100% of their torque—that head-snapping, teeth-rattling jolt of wheel-turning adrenaline—as soon as you crack the throttle. A gasoline-powered motor gives you almost no power until it gets its revs up. From there, an electric motor continues to dish out power as it spins up; if you want to go faster, you just give it more voltage and spin the motor faster. Gas motors have very narrow bands of power, which is why a transmission is needed to spread that power over all the speeds. Most electric motorcycles don't use or need a transmission.

Riding one of these, even one of the smaller bikes, is like having instant power at your fingertips. Riding the big bikes can only be described as holding yourself hooked to the end of a big, long bungee cord and then letting go. From 0 to the motorcycle's top speed, it's a simple twist of the throttle and you're gone. There's nothing to think about, except negotiating the road—no concentrating on engine speed or when to shift. This is a new experience and a new way to understand motorcycling.

Are electric cycles as fast as gas bikes? Yes, they can be. Electric bikes have competed, and sometimes won, against a field of gasoline-powered bikes. In racing, there's the "class" issue—you've got to determine the proper weight and power class to ensure a fair match. But clearly, they can hold their own. As the technology develops, they will no doubt surpass gas performance—the all-electric Grand Prix (the TTXGP) is only entering its third year.

What's Next?

The main development in electric vehicles is the battery system. Lithium-ion battery technology continues to progress and, as the supply and technology ramps up, prices are dropping dramatically. We may soon see even lighter, less-expensive batteries with greater capacity. But the lead-acid battery technology that is more than a century old remains a viable option for low-cost, reliable, and long-lasting systems.

As the all-electric car market ramps up and starts to drive demand, the charging infrastructure grows, and much of the prejudice about electric vehicles fades away, the personal electric vehicle, in whatever form you're looking for, is here to stay.

Access

Ted Dillard (ted@evmc2.com) is the author of www.ElectricChronicles.com, a website devoted to two-wheel electric vehicles of all descriptions, renewable energy and EV technology, and of "...from Fossils to Flux," a basic guide to building an electric motorcycle. He's had an unhealthy obsession with EVs since his first ride in a Renault Mars II in 1968.

Manufacturers:

- Brammo • www.brammo.com • Electric motorcycle
- Crystalyte • www.crystalyte.com • Electric bike conversion kit
- Current Motor Co. • www.currentmotor.com • Electric scooter
- E-Glide • www.e-glide.com • Electric scooter
- Electric Motorsport • www.electricmotorsport.com • Electric scooter
- Golden Motor • www.goldenmotor.com • Electric bike conversion kit
- Hollywood Electrics • www.hollywoodelectrics.com • Electric scooter
- Mission • www.ridemission.com • Electric motorcycle
- Motoczysz • www.motoczysz.com • Electric motorcycle
- Quanta • www.quantausa.com • Electric motorcycle
- Razor • www.razor.com • Electric scooter
- Roehr Motorcycles • www.roehrmotorcycles.com • Electric motorcycle
- Schwinn • www.schwinnbikes.com • Electric bike
- Segway • www.segway.com • Electric transporter
- Trek • www.trekbikes.com • Electric bike
- Ultra Motor • www.ultramotor.com • Electric bike
- Vectrix • www.vectrix.com • Electric scooter
- Zero Motorcycles • www.zeromotorcycles.com • Electric motorcycle

