

Electric motorcycles and scooters

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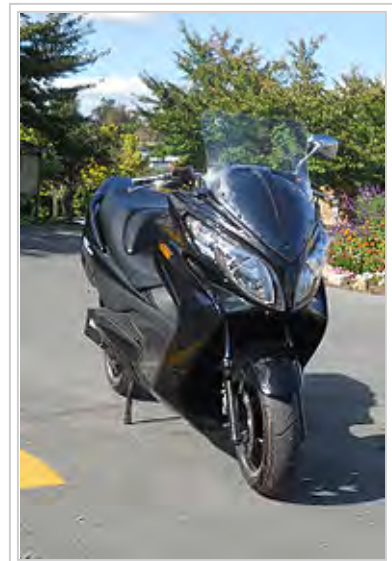
Electric motorcycles and scooters are plug-in electric vehicles with two or three wheels powered by electricity. The electricity is stored on board in a rechargeable battery, which drives one or more electric motors. Electric scooters (as distinct from motorcycles) have a step-through frame.

Electric motorcycle manufacturers include Victory Motorcycles, Monday Motorbikes, Zero Motorcycles, Lightning Motorcycle, Energica Motor Company, Johammer, Quantya, Electric Motorsport, Hollywood Electrics, Yo, Lito, Gogoro Rondine Motor and Alta Motors.^[1] Yamaha plans to enter the market shortly with at least two models.^[2] Spanish company Bultaco entered the electric motorcycle market in 2015.^[3] Heavyweight Harley-Davidson introduced a new prototype electric motorcycle in June 2014.^[4] Z Electric Vehicle introduced a full fairing sports style motorcycle in September 2015.^[5]

Z Electric Vehicle is a US based commercial production supplier of electric scooters for worldwide markets.^[6] The BMW C Evolution electric scooter was released in Germany in May 2014.^[7] Honda participated in European lease demonstration and driving tests for its electric scooter in 2012 but has not yet announced its availability for sale.^[8] Terra Motors, a Japanese electric vehicle maker, will begin selling electric scooters in India by 2015.^[9] Gogoro announced a swappable battery electric scooter at CES 2015.^[10] eGen is a UK based company offering a variety of electric scooters utilising lithium iron phosphate batteries^[11]



Zero DS (motorcycle)



ZEV LRC (scooter)

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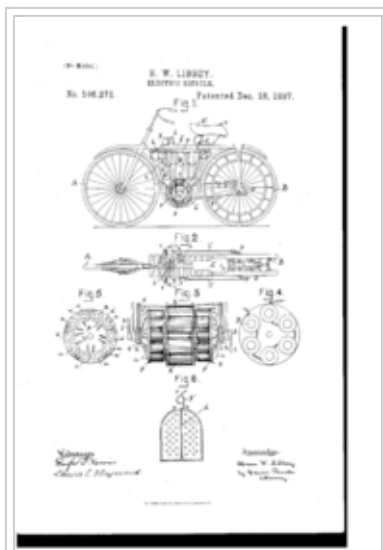


eGen eG3 electric scooter

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History

1895 to 1950



Patent drawing for an "Electric Bicycle" (1895)

The early history of electric motorcycles is somewhat unclear. On 19 September 1895, a patent application for an "electrical bicycle" was filed by Ogden Bolton Jr. of Canton Ohio.^[12] On 8 November of the same year, another patent application for an "electric bicycle" was filed by Hosea W. Libbey of Boston.^[13]

At the Stanley Cycle Show in 1896 in London, England, bicycle manufacturer Humber exhibited an electric tandem bicycle. Powered by a bank of storage batteries, the motor was placed in front of the rear wheel. Speed control was by a resistance placed across the handlebars. This electric bicycle was mainly intended for racetrack use.^[14]

The October 1911 issue of Popular Mechanics mentioned the introduction of an electric motorcycle. It claimed to have a range of 75 miles (121 km) to 100 miles (160 km) per charge. The motorcycle had a three-speed controller, with speeds of 4 miles (6.4 km), 15 miles (24 km) and 35 miles (56 km) per hour.^[15]

Timeline	
1895	Earliest known electric motorcycle patent.
1911	Popular Mechanics article introduces an electric motorcycle.
1919	Ransomes, Sims & Jefferies make an electric motorcycle prototype.
1936	Socovel electric motorcycle company founded.
1946	Marketeer company founded, based on an electric motorcycle made by Merle Williams.
1967	Karl Kordesch makes an

In 1919, Ransomes, Sims & Jefferies made a prototype electric motorcycle in which the batteries were fitted under the seat of the sidecar. Even though the vehicle was registered for road use, it never went past the trial stage.^[16]

In 1936, the Limelette brothers founded an electric motorcycle company called Socovel (**S**ociété pour l'étude et la **C**onstruction de **V**ehicules **E**lectriques or Company for research and manufacture of electric vehicles) in Brussels. They continued production during the German occupation with their permission. Due to fuel rationing, they found some degree of success. But after the war, they switched to conventional models. The electric models remained available until 1948.^{[17][18][19]}

During the World War II, compelled by fuel rationing in the United States, Merle Williams of Long Beach, California invented a two-wheeled electric motorcycle that towed a single wheeled trailer. Due to the popularity of the vehicle, Williams started making more such vehicles in his garage. In 1946, it led to the formation of the Marketeer Company (current-day ParCar Corp.).^[20]

1950 to 1980

In 1967, Karl Kordesch, working for Union Carbide, made a fuel cell/Nickel–cadmium battery hybrid electric motorcycle. It was later replaced with a hydrazine fuel cell, giving it a range of 200 miles (320 km) per gallon and a top speed of 25 mph (40 km/h).^{[21][22]}

In the same year, a prototype electric motorcycle called the Papoose, was built by the Indian Motorcycle Company under the direction of Floyd Clymer.^[23]

In 1974, Auranthic Corp., a small manufacturer in California, produced a small motorcycle called the Charger. It had a 30 mph (48 km/h) and a 50 miles (80 km) range on a full charge.^[24]

In the early 1970s, Mike Corbin built a street-legal commuter electric motorcycle called the Corbin Electric. Later in 1974, Corbin, riding a motorcycle called the Quick Silver, set the electric motorcycle speed world record at 165.387 mph (266.165 km/h). The motorcycle used a 24 volt electric starter motor from a Douglas A-4B fighter plane.^[25] In 1975, Corbin built a battery-powered prototype street motorcycle called the City Bike. This motorcycle used a battery manufactured by Yardney Electric.^[26]

In June 1975, the first Annual Alternative Vehicle Regatta was held at Mt. Washington, New Hampshire. The event was created and promoted by Charles McArthur, an environmentalist. On June 17, Corbin's motorcycle completed the 8 miles (13 km) uphill course in 26 minutes.^[27]

1980 to 2000

In 1988, Ed Rannberg, who founded Eyeball Engineering, tested his electric drag motorcycle in Bonneville.^[28] In 1992, the January issue of Cycle World carried an article about Ed Rannberg's bike called the KawaSHOCKI. It could complete a quarter mile (0.25 miles (400 m)) in 11–12 seconds.^[25]

	hydrazine fuel cell motorcycle
1974	Mike Corbin's motorcycle Quick Silver sets electric motorcycle speed record of 165.387 mph (266.165 km/h)
1996	First mass-produced electric scooter, Peugeot Scoot'Elec, released
2011	Chip Yates sets Guinness record of fastest electric motorcycle with 316.899 km/h (196.912 mph)
2013	First FIM eRoad Racing World Cup

In 1995, Electric Motorbike Inc. was founded by Scott Cronk and Rick Whisman in Santa Rosa, California. In 1996, EMB Lectra was built by Electric Motorbike Inc., which used a variable reluctance motor.^[29] It had a top speed of about 45 mph (72 km/h) and a range of 35 miles (56 km). About a 100 of these were built.^[30]

In 1996, the first mass-produced electric scooter, Peugeot Scoot'Elec, was released. It used Nickel-Cadmium batteries and a range of 40 km (25 mi).^[31]

2000 to present



TTXGP bikes at Isle of Man TT 2009

On 26 August 2000, Killacycle established a drag racing record of completing a quarter mile (400 m) in 9.450 seconds on the Woodburn track in Oregon. Killacycle used lead acid batteries at a speed of 152.07 mph (244.73 km/h).^[32] Later, Killacycle using A123 Systems Li-ion nano-phosphate cells set a new

quarter mile record of 7.824 seconds breaking the 8 seconds barrier at 168 miles per hour (270 km/h) in Phoenix, Arizona at the All Harley Drag Racing Association (AHDRA) 2007, on 10 November 2007.^[33]



Chip Yates at Bonneville in 2011

On 4–5 April 2009, Zero Motorcycles hosted the "24 Hours of Electricross" event in San Jose. It is considered the first all-electric off-road endurance race.^[34]

On 14 June 2009, the first electric Time Trial Xtreme Grand Prix (TTXGP) all electric street motorcycle race took place on the Isle of Man in which 13 machines took part. Rob Barber riding a motorcycle built by Team Agni won the race. He completed the 37.73 miles (60.72 km) course in 25 minutes 53.5 seconds, an average speed of 87.434 miles per hour (140.711 km/h).^[35]

In 2010, ElectroCat, made by Eva Håkansson, set the record time for an electric motorcycle to climb Pikes Peak. The motorcycle, ridden by John Scollon, completed the 12 miles (19 km) course in 16 minutes 55.849 seconds. ElectroCat uses batteries manufactured by A123 Systems.^[36]

On 26 June 2011, Chip Yates broke ElectroCat's previous record at Pikes Peak. He completed the course in 12 minutes 50.094 seconds.^[37] On 30 August 2011, Yates riding his prototype SWIGZ.COM electric superbike established the official Guinness record of the fastest electric motorcycle. The motorcycle clocked a speed of 316.899 km/h (196.912 mph) at Bonneville.^[38]

In 2012, Paul Ernst Thede set an SCTA record run of 216.8 miles per hour at Bonneville Salt Flats, Utah. This did not qualify as a Guinness World record as it wasn't timed by the FIM timing association.

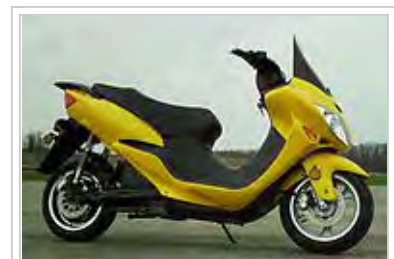
On 30 June 2013, Carlin Dunne riding a Lightning Motorcycle-built electric bike beat conventional motorcycles at Pikes Peak. He clocked a 10 minutes 00.694 seconds at the 12.42 miles (19.99 km) course. Bruno Langlois riding a Ducati Multistrada 1200 S finished second with a time of 10 minutes 21.323 seconds.^{[39][40]}

Vectrix in 2006 introduced the first commercially available high performance electric scooter, the VX-1. Following insolvency and initial bankruptcy reorganization, the Gold Peak battery group purchased the company in 2009. Vectrix expanded product lines, offering the VX-2 and the three wheeled VX-3. But Vectrix ceased operations in January 2014 and filed for Chapter 7 bankruptcy liquidation, with its remaining assets auctioned off the following June.^{[41][42]}

Power source

Most electric motorcycles and scooters today are powered by rechargeable lithium ion batteries, though some early models used nickel-metal hydride batteries.

Alternative types of batteries are available. Z Electric Vehicle has pioneered use of a lead/sodium silicate battery (a variation on the classic lead acid battery invented in 1859, still prevalent in automobiles) that compares favorably with lithium batteries in size, weight, and energy capacity, at considerably less cost.^[43] EGen says its lithium-iron phosphate batteries are up to two-thirds lighter than lead acid batteries and offer the best battery performance for electric vehicles.^[11]



ZEV 7100LR (lead/sodium silicate battery)

Charging

All electric scooters and motorcycles provide for recharging by plugging into ordinary wall outlets, usually taking about eight hours to recharge (i.e. overnight). Some manufacturers have designed in, included, or offer as an accessory, the high-power CHAdeMO level 2 charger, which can charge the batteries up to 95% in an hour.^[44]



Yamaha FC-AQEL (fuel cell prototype)

Battery swapping

Manufacturers like Zero Motorcycles and recent entrants to the scooter market Gogoro and Unu have designed machines that allow quick battery swapping, for apartment dwellers who do not have a garage outlet, or for an instant recharge on the go.^{[10][44][45][46]}

Hybrid

Honda has developed an experimental internal combustion/electric hybrid scooter.^[47] Yamaha has also developed a hybrid concept motorcycle called Gen-Ryu. It uses a 600cc engine and an additional electric motor.

^[48] Piaggio MP3 Hybrid uses a 125cc engine and an additional 2.4 kW motor.^[49]



Suzuki Burgman (fuel cell prototype)

Fuel cell

There are several experimental prototypes using fuel cell technology. ENV developed by Intelligent Energy is a hydrogen fuel cell prototype. The motorcycle has a range of 100 miles (160 km) and can reach a top speed of 50 mph (80 km/h).^[50] Suzuki has also developed a concept hydrogen fuel cell scooter based on the Suzuki Burgman.^[51] Yamaha has created a hydrogen fuel cell prototype called FC-AQEL, which is considered equivalent to a 125cc vehicle.^[52] Honda has also developed a hydrogen fuel cell scooter which uses the Honda FC Stack.^[47]

Electric vs. gasoline machines

Performance

Electric and gasoline powered motorcycles and scooters of the same size and weight are roughly comparable in performance.^[53] In August 2013 Road and Track evaluated a high-end electric motorcycle as faster and better handling than any conventionally powered bike.^[54] Electric machines have better 0 to 60 acceleration, since they develop full torque immediately, and without a clutch the torque is instantly available.^{[55][56]}

Range

Electric motorcycles and scooters suffer considerable disadvantage in range, since batteries cannot store as much energy as a tank of gas.^[57] Anything over 130 miles (210 km) on a single charge is considered an exceptionally long range.^[58] As a result, while electric machines excel as daily commuters traveling a fixed distance round trip, on the open road riders experience inhibiting range anxiety.^[59] Also electric power trades off range against speed. For instance the current longest range electric scooter, the ZEV 10 LRC, travels 220 km (140 mi) at 89 km/h (55 mph), but according to the manufacturer the range drops to about 129 km (80 mi) at 112 km/h (70 mph).^[60] A BBC news blog reported that an Austrian bike, the Johammer J1, is capable of travelling 200 km (124 miles) on a single charge.^[61]

Maintenance

Electric scooters and motorcycles need very little maintenance. As Wired magazine's transportation editor Damon Lavrinc reported after an experiment of trying to go six months using nothing but a Zero electric motorcycle: "[w]ith only a battery, a motor, and a black box (i.e. the controller) to keep you moving, electric motorcycles are a breeze to maintain compared to a conventional motorcycle, what with all the lubricating and adjusting and tuning you have to do. You basically just worry about consumables: brake pads, tires, maybe a brake fluid flush. That's about it."^[62] Electric scooters and motorcycles equipped with regenerative braking typically have longer brake pad life because a significant portion of braking duty can be performed with the electric motor instead of the mechanical friction brakes.



Brandon Nozaki Miller on the first production electric motorcycle to break 161 km/h (100 mph), a 2012 Zero S ZF6 at Bonneville Salt Flats (2012)

Fuel cost

At between one and two cents per mile (depending on electric rates), electric machines enjoy an enormous fuel cost advantage. Three months and 2,800 km (1,700 mi) of commuting on an electric motorcycle cost Lavrinc less than \$30 for electricity; on a BMW gasoline bike a single trip of 650 km (400 mi) cost nearly the same. In Australia, UBCO battery Electric Motorbike running cost is 88¢ per 100 km^{[57][63]}

Noise

Electric vehicles are far quieter than gas powered ones, so silent they may sneak up on unwary pedestrians.^[64] Some are equipped to emit artificial noise. Popular Mechanics called the comparative quiet of electric motorcycles the greatest difference between them and their gas counterparts, and a safety bonus because the rider can hear danger approaching.^[65] Whether a loud motorcycle is more noticeable and thus more safe than a quiet one is contested.^{[66][67]} At high speed the whine of an electric motorcycle is said to sound "like a spaceship."^{[68][69]}

Sales and adoption

China leads the world in electric scooter sales, comprising 9.4 million of the total 12 million sold worldwide in 2013. There were only 31,338 electric scooter sales outside the Asia-Pacific region including Europe. The US market is comparatively small, with an estimated 2,000 sold in 2012.^[70]

While steadily becoming more practical, high prices and a limited range suited best for commuting have been impediments to electric motorcycles and scooters increasing their market share.^[71] In the US at least, cheaper motorcycles that can refuel in minutes at any gas station better suit weekend riders, the predominant users.^[72] According to a market report published in 2013, the sales of electric motorcycles and scooters is expected to rise over 10-fold by 2018 in North America, to about 36,000 by 2018.^[73]

In India, high costs and power grid problems have contributed to slow sales. In states like Tamil Nadu, where power supply of rationed electricity was reduced, a corresponding drop in sales has been observed by electric scooter manufacturers like Ampere and Hero Electric.^[74]

Government promotion and incentives

India

In January 2013, the Indian government announced a plan to provide subsidies for hybrid and electric vehicles. The plan will have subsidies up to ₹ 150000 for cars and 50000 on two wheelers. India aims to have seven million electric vehicles on the road by 2020.^[75]



Electric Scooter in Berlin. Designed for an app based sharing system.

Taiwan

The premier of the Republic of China (Taiwan) Liu Chao-shiuan said in 2008 that the government-financed Industrial Technology Research Institute (ITRI) will help domestic manufacturers mass-produce 100,000 electric motorcycles in four years.

Motorsports

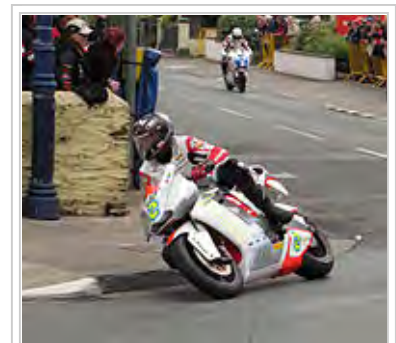
Pikes Peak International Hill Climb (PPIHC)

The Pikes Peak International Hill Climb began in 1916 and is the second oldest motor sports race in America. The PPIHC is a long-standing tradition in the Colorado Springs and Pikes Peak Regions. The race takes place on a 12.42 mile course beginning at 9,390 feet with 156 turns and ending at the 14,110 foot summit of Pikes Peak. One of the main obstacles of the race is the increasingly thin air that slows reflexes, diminishes muscle strength and reduces the power of internal combustion engines by 30 percent as competitors advance up the peak. The electric motorcycle division has an advantage with the all-electric motorcycles because they do not experience power loss with increased elevation and thinner air.

The Lightning Motorcycle Super-bike electric motorcycle set the fastest overall time in the motorcycle division, beating all gas powered motorcycles in 2013.^{[39][40]}

TT Zero

TTXGP was conceived by Azhar Hussain. The first race was held on 30 June 2009 on the Isle of Man in which 13 teams took part.^[35] The event was endorsed by the Fédération Internationale de Motocyclisme (FIM).^[76] In May 2010, TTXGP started a world championship series.^[76] It went on to organize several races in US, Europe and Australia.^[77] In 2010, TT Zero replaced the TTXGP event in the Isle of Man TT race. Neither TTXGP nor Azhar Hussain were involved in the event. The event followed FIM rules.^[76]



Mark Miller riding a MotoCzysz E1pc at TT Zero (2012)

FIM eRoad Racing World Cup

On 18 November 2010, Fédération Internationale de Motocyclisme (FIM) announced an ePower International Series for electric motorcycles, causing a split between TTXGP promoters and FIM.^[78] FIM, unlike TTXGP, was unable to gather many teams of the series. In March 2011, TTXGP announced it would again collaborate with FIM.^[79]

In 2013, TTXGP and FIM collaborated to organize the FIM eRoad Racing World Cup with races in US, Europe and a final race in Asia.^[77]

Motocross

In 2013, FIM announced an all-electric event, called E-MX, which was held in Belgium during Clean Week 2020 on 2 May.^[80] MiniMoto SX Energy Crisiscross is a regular event where electric off-road motorcycles are allowed to compete against conventional motorcycles.^[81]

eMotoRacing

After the TTXGP concluded its 2013 race season, it pulled out of the US, and Arthur Kowitz, who had participated in the FIM eRoad Racing World Cup founded eMotoRacing (<http://eMotoRacing.com>) to fill the void.

^[82] eMotoRacing kicked off its first season in 2014, running in conjunction with AHRMA which gave access to ten high-profile tracks around the US. In addition to its regular race season, eMotoRacing held its first annual "Varsity Challenge" on July 11–13, 2014^[83] at the New Jersey Motorsports Park, urging engineering teams from universities to race custom-built electric motorcycles. At the start of its third season in 2016, AHRMA announced it had adopted eMotoRacing's "eSuperSport" class as a permanent addition to their road racing lineup.^[84]

See also

- Electric kick scooter
- Electric trike
- Electric vehicle conversion
- Energy density
- Government incentives for plug-in electric vehicles
- List of modern production plug-in electric vehicles (includes electric motorcycles)
- Miles per gallon gasoline equivalent
- Mobility scooter
- Plug-in electric vehicle

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A Brammo Engage at MiniMoto SX (2011)



eMotoRacing (<http://eMotoRacing.com>) founder Arthur Kowitz, and Pete Nicolosi, 2016 series points leader (as of race #6), vie for the lead during 2016's 1st race, held at Roebing Road, GA.

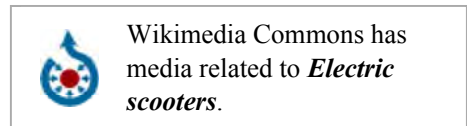
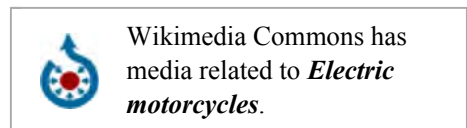
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