

# Nickel–zinc battery

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A **nickel–zinc battery**, abbreviated **NiZn**, is a type of rechargeable battery that may be used in cordless power tools, cordless telephones, digital cameras, battery operated lawn and garden tools, professional photography, flashlights, electric bikes, and light electric vehicle sectors, among other uses.

Larger nickel–zinc battery systems have been known for over 100 years. Since 2000, development of a stabilized zinc electrode system has made this technology viable and competitive with other commercially available rechargeable battery systems.

## Nickel–zinc battery

<b>Specific energy</b>	100 W·h/kg
<b>Energy density</b>	280 W·h/L
<b>Specific power</b>	> 3000 W/kg
<b>Energy/consumer-price</b>	2–3Wh/US\$
<b>Nominal cell voltage</b>	1.65 V

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## History

In 1901, Thomas Alva Edison was awarded U.S. Patent 684,204 (<https://www.google.com/patents/US684204>) for a rechargeable nickel–zinc battery system.<sup>[1]</sup>

The battery was later developed by the Irish chemist Dr. James J. Drumm (1897–1974),<sup>[2]</sup> and installed in four two-car Drumm railcar sets between 1932 and 1948 for use on the Dublin–Bray railway line. Although successful, they were withdrawn when the batteries wore out. Early nickel–zinc batteries were plagued by a limited number of discharge/recharge cycles. In the 1960s, nickel–zinc batteries were investigated as an alternative to silver–zinc batteries for military applications, and in the 1970s, were again of interest for electric vehicles.<sup>[3]</sup> A company called *Evercel Inc.* developed and patented several improvements in nickel–zinc batteries, but withdrew from that area in 2004.<sup>[4]</sup>

## Applications

Nickel–zinc batteries have a charge/discharge curve similar to 1.2 V NiCd or NiMH cells, but with a

higher 1.6 V nominal voltage.<sup>[5]</sup>

Nickel–zinc batteries perform well in high-drain applications, and may have the potential to replace lead–acid batteries because of their higher energy-to-mass ratio and higher power-to-mass ratio — as little as 25% of the mass for the same power.<sup>[6]</sup> NiZn are cheaper than nickel-cadmium batteries,<sup>[6]</sup> and are expected to be priced somewhere in between NiCd and lead–acid types. NiZn may be used as a substitute for nickel–cadmium. The European Parliament has supported bans on cadmium-based batteries,<sup>[1]</sup> and nickel–zinc offers the European power tool industry a good alternative.

After about 30 cycles, the self-discharge rate may increase, so after charging the batteries may not stay "fresh" as long. For applications requiring high-power and high-voltage, NiZn is a good battery choice when superior charge-retention is not required.<sup>[7]</sup>

However, if used properly, NiZn batteries can last for hundreds of cycles.<sup>[8]</sup>

## Battery life

Compared with cadmium hydroxide, the tendency of zinc hydroxide to dissolve into solution and not fully migrate back to the cathode during recharging has, in the past, presented challenges for the commercial viability of the NiZn battery.<sup>[1][3]</sup> The zinc's reluctance to fully return to the solid electrode adversely manifests itself as shape change and dendrites (or "whiskers"), which may reduce the cell discharging performance or, eventually, short out the cell, resulting in a low cycle life.

Recent advances have enabled manufacturers to greatly reduce this problem. These advances include improvements in electrode separator materials, inclusion of zinc material stabilizers, and electrolyte improvements (i.e. by using phosphates). One manufacturer, (PowerGenix), which has developed 1.6V batteries, has claimed battery cycle life comparable to NiCd batteries.<sup>[9]</sup>

Battery cycle life is most commonly specified at a discharge depth of 80 percent of rated capacity and assuming a one-hour discharge current rate. If the discharge current rate is reduced, or if the depth of discharge is reduced, then the number of charge-discharge cycles for a battery increases. When comparing NiZn to other battery technologies, cycle life specifications may vary with other battery technologies, depending on the discharge rate and depth of discharge that were used.

## Advantages

Nickel–zinc cells have an open circuit voltage of 1.85 volts when fully charged,<sup>[10]</sup> and a nominal voltage of 1.65 V. This makes NiZn an excellent replacement for electronic products that were designed to use alkaline primary cells (1.5 V). NiCd and NiMH both have nominal cell voltages of 1.2 V, which may cause some electronic equipment to shut off prior to a complete discharge of the battery because the minimal operating voltage is not provided.

Newer, more powerful cells with up to 800 cycles/life can be an alternative to Li-Ion batteries for electric vehicles. Due to their higher voltage, fewer cells are required (compared to NiCd and NiMH) to achieve a given battery-pack voltage, reducing pack weight and size and improving pack reliability. They also have low internal impedance (typically 5 milliohms), which allows for high battery discharge rates, up to  $50C$ . ( $C$  is battery capacity in Ah, divided by one hour.)

NiZn batteries do not use mercury, lead, or cadmium, or metal hydrides which can be difficult to recycle.<sup>[11]</sup> Both nickel and zinc are commonly occurring elements in nature, and can be fully recycled.

NiZn cells use no flammable active materials or organic electrolytes, and the newest models use polymeric separators which reduces the dendrites problem.

Properly designed NiZn cells can have very high power density and low temperature discharging performance, and also can be discharged to 100% and recharged without problems. They are now available in sizes up to F and 50Ah/ prismatic cell.

Zinc is cheap and abundant metal (the 24th most abundant element in the Earth's crust) and it is not dangerous to health. Common oxidation is +2 so charge and discharge move two electrons instead of one as in NiMH batteries.

## Charging

NiZn technology is well suited for fast recharge cycling, as optimum charge rates of  $C$  or  $C/2$  are preferred.<sup>[12]</sup>

Known charging regimes include a constant current of  $C$  or  $C/2$  to cell voltage = 1.9 V. Maximum charge time is given variously as 2½ hours<sup>[12]</sup> and 3 hours.<sup>[13]</sup> Trickle charging is not recommended, as recombination is not provided for, and excess hydrogen will eventually vent, adversely affecting battery cycle life.

## See also

- Comparison of battery types
- List of battery sizes
- List of battery types
- Nickel–cadmium battery
- Zinc–air battery

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