What to Know About NiZn Cells

http://www.amazon.com/review/RQFY1NUK4L58V

Customer Review

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Showdown: PowerGenix NiZn vs. SANYO eneloop NiMH, October 28, 2009
By
NLee the Engineer
This review is from: PowerGenix ZRPGX-AA8 AA 1.6v 2500 mWh ZiNc High-Voltage Rechargeable Batteries -8 Pack (Green) (Electronics)
The product description of PowerGenix Nickel-Zinc Rechargeable AA cell promises many advantages over other rechargeable batteries: higher voltage, higher energy density, lighter weight, longer cycle life, and so on. But how does it stack up against the current gold-standard of low-self-discharge NiMH cell, the Sanyo Eneloop? Let's examine the following aspects:

[Operating Voltage]
The NiZn cell has a nominal voltage of 1.65V, which is 30% higher than that of a NiMH cell (1.25V nominal). When freshly charged, its terminal voltage is even higher at 1.85V!

[Power Density]
Since 'Power' is defined as 'Voltage * Current', most people may assume that "30% higher Voltage" translates to "30% higher Power". But it depends on the application:

- Most electronic gadgets (digital camera, MP3 player, etc) contain internal DC/DC regulators which operate in constant-power mode. If the battery voltage is higher, then input current will drop to maintain the same output power. That's why higher voltage alone does not make your digital camera shoot any faster.
(One exception is photo flash unit, which operates in constant-current mode. So in this case, 30% higher voltage does translate to 30% higher power and shorter cycle time)

- For an unregulated appliance such as a flashlight or power tool, its current increases with voltage (although not linearly). A typical 2-AA flashlight bulb is rated for 2.3V * 0.5A = 1.15W. When you apply 3.6V to it, the current may increase to 0.65A, so the power consumption is now 3.6V * 0.65A = 2.3W. Twice the power means twice the heat. That's why the bulb may burn out in seconds.

[Energy Density]
The PowerGenix AA cells are marketed as "2500 milli-WATT-hour" (energy capacity). Most people may confuse this with "2500 milli-Ampere-hour" (charge capacity). But the data sheet for NiZn AA cell shows that its current capacity is only 1500mAh (this is verified by my own testing). It turns out that an 1500mAh NiZn cell actually contains the same amount of energy as a 2000mAh SANYO eneloop AA cell:

- Energy in eneloop AA cell: 1.25V * 2000mAh = 2500mWh
- Energy in PowerGenix AA cell: 1.65V * 1500mAh = 2475mWh

[Weight]

The weight of each NiZn AA cell (25g) is essentially the same as that for eneloop AA cell (27g). For certain applications, it is possible to use three NiZn cells (3*1.65=5V) to replace four NiMH cells (4*1.25V=5V). Doing so reduces battery weight by 25%, but it also shortens run time by 25%.

[Cycle Life]
Technical data found on PowerGenix web site says NiZn cells are rated for 200 cycles (at 100% deep-discharge). This is much shorter than the 1000 cycles cited for eneloop cells.

I have tested a set of 4 PowerGenix AA cells. After subjecting them through 12-16 deep discharge cycles, the average charge capacity already dropped 5% from original value. In comparison, I have a set of 4 eneloop AAA cells that have went through about 100 cycles in the past 2.5 years, and they still exhibit over 95% of original capacity.

[Self-Discharge Rate]
In my long-term storage test after two months, a set of four NiZn cells retained 74% original charge capacity on average. This translates to about 13% loss per month, which is much better than that of ordinary high-capacity NiMH batteries (with capacity > 2500mAh). But it cannot compare to low-self-discharge NiMH cells.

Previously, I have conducted storage test for several brands of LSD cells, including Sanyo eneloop, Rayovac Hybrid, and Kodak Pre-Charged. All those cells can retain 85-90% of original capacity after FIVE months in storage.

[Recharging Time]
The PowerGenix NiZn cells must be recharged using a specially designed PowerGenix NiZn Charger. The charger is called '1-hour', but it actually takes 2.5 hours to fully recharge a set of four 1500mAh cells.

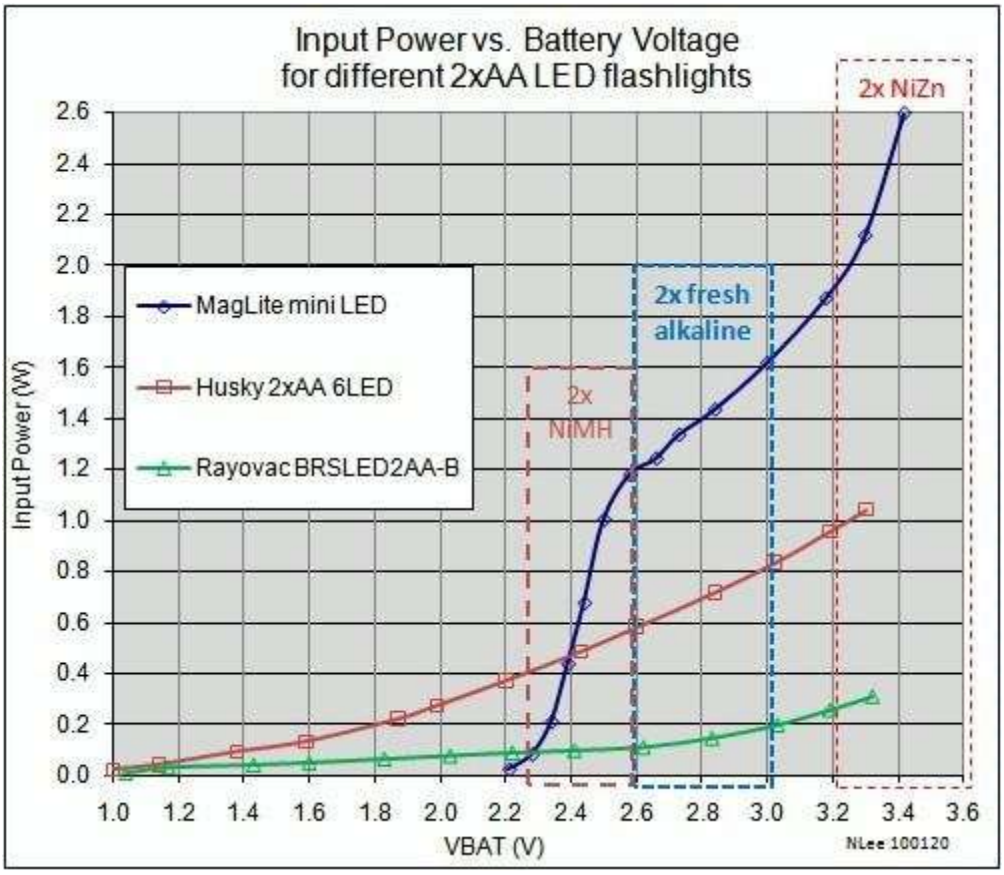
Eneloop (and all other brands of LSD cells) can be recharged using any good quality 'smart' NiMH charger. Depending on which charger you use, the charge time can be as short as 15 minutes, or as long as 8 hours.

[BOTTOM LINE]
The only verifiable benefit for PowerGenix NiZn cell is its higher operation voltage. However, even this may turn out to be a curse rather than a blessing, as higher voltage can cause unregulated appliances to burn out.

If you have a digital camera that works well with eneloop, stay with it. Switching to NiZn will not offer more power, nor longer run time. Only if your camera does not work well with eneloop, then it is worthwhile to try NiZn cells as a last resort. But you better contact PowerGenix, and ask whether they will assume warranty liability for the use in your camera. Otherwise, try it at your own risk!

[Update on Nov 21, 2010]
My first set of four NiZn cells was used for capacity testing and long-term self-discharge testing. They have gone though maybe 20-30 deep discharge/recharge cycles (discharged down to 0.9V only, not 0V) over the past year. As of right now, two out of four cells have already failed, suffering from voltage depression and rapid self-discharge

problems. The other two suffered from reduced capacity (~1200mAh, down from the original 1500mAh). The PowerGenix '1-hour' charger needs to detect 1.9V during charging, before it can change from constant-current mode to constant-voltage mode. When voltage-depression hits a cell, its voltage cannot reach 1.9V during charging, so the NiZn charger will simply fry the cell!



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http://michaelbluejay.com/batteries/

NiZn (Nickel-Zinc) -- A good rechargeable, better & worse than NiMh in some ways

Pros:

- Rechargeable
- Works great in high-drain devices
- Lasts longer in some high-drain devices than NiMH's

- Higher voltage (1.65V+) makes lights burn brighter (except some LED's which regulate the voltage)

Cons:

- The high voltage (1.65V) can burn out lights quicker, fry some electronics with no voltage regulator, and just not work in some electronics that do have voltage regulators
- High self-discharge rate (they lose ~13% of their initial charge per month just sitting around)
- Capacity plummets as the cells are cycled (used & recharged)
- Requires a special, proprietary charger.
- Possible reliability problems (high failure rate: cells die quickly or self-discharge even faster than normal)
- They're ever-so-slightly larger than normal, so they might not fit in those rare devices in which the batteries are already a tight fit.
- Semi-discontinued (see below; for now, Amazon has them, and the charger)
- Not available in any sizes besides AA and AAA

Intro. NiZn's were introduced by PowerGenix in 2009 as an alternative to NiMH's. Their gimmick is that they have a higher voltage, so they're a solution for devices in which the 1.2V of NiMH cells is too low. The higher voltage also means that camera flashes power up faster and flashlights burn brighter. But the higher voltage could be both a blessing and a curse, with the higher voltage burning out lights and sensitive electronics, as we'll see below. PowerGenix made them in only the AA size, and then discontinued them, but off-brands from China are available on eBay.

Where to Buy. PowerGenix made NiZn for only a year or two, then stopped. In June 2012, they informed me that they're talking to other companies about having them take over production, but I'll believe it when I see it. In the meantime, the unsold stock is still available at Amazon as I write this, and when that's gone, lots of Chinese retailers sell no-name and off-brand NiZn's on eBay. (Yes, quality could be an issue, but if you want the extra voltage from NiZn's, your options are limited. And in fact, even the PowerGenix brand wasn't all that reliable. More on that in a minute.) Remember that

you'll need a *special charger*, and that's the same deal as the batteries: Buy the PowerGenix one before they're all gone, or get a no-name Chinese brand from eBay.

Reliability. PowerGenix NiZn's suffer from reliability problems. See below for my poor experience with capacity. Also, NLee reports that after buying four cells and putting them through 20-30 deep cycles (0.9V), two failed (reduced voltage and rapid self-discharging), and the other two suffer from reduced capacity (80% of original). Many customers on Amazon report their batteries dying prematurely too. It appears that over-discharging NiZn's, which can easily damage them. (NiMH's are more tolerant of an over-discharge.)

High-Drain Performance. High-drain devices are those which need lots of power quickly, like digital cameras. That's as opposed to devices that just sip the juice slowly, like clocks. NiZn work great in high-drain devices, if the voltage isn't an issue. (See the Voltage section below.)

Capacity and Run Time. There are many reports of reliability problems, including my own experience, which kind of make any published specs about capacity moot. I used 9 for about a year (probably fewer than 10 cycles) in electric toothbrushes and electronic door locks. Seven of the nine (Star Trek Voyager reference unintentional) dropped to only 45-150mAh in capacity, and the remaining two were 996 and 1298mAh. They should have been 2500mWh ÷ 1.65V = 1515mAh. NLee the Engineer says that after just a year, 2 of the 4 he purchased suffered reduced capacity down to 80% of the original, and the other 2 simply failed. Many others have made similar complaints. The following discussion assumes that NiZn's don't suffer reduced capacity early, although that's probably not the case.

NiZn's give either longer, shorter, or fairly equal run time, depending on what device you use them in. engadget said that they got 300-400 flashes from their camera flash unit with NiZn's, vs. only 200-300 with NiMH's, and Tom's Guide said their NiZn's ran a CD player for three times longer than NiMH's. However, devices which don't limit the input voltage (like most flashlights and electric toothbrushes, for example) will run out faster with NiZn's, because while the device was running the light was burning brighter or the motor was spinning faster. NiZn's will make camera flashes recycle much faster, though burning through lots of flash shots quickly can fry the flash. Also, the NiZn will

likely not give as many total flashes as NiZn, so you get super-fast flash recycle times at first, but then it gets worse than NiMH. (Strobist quotes a user that said NiZn's got worse after 50-75 shots, and too slow to use after 200 shots, compared to 400 shots for NiMH.)

Usually battery capacity varies from brand to brand, but in this case there's only one brand so the AA and AAA capacities are 1500 and 700 mAh respectively. That's about half of the best NiMH's. PowerGenix therefore lists the spec on its battery in mWh (total energy) rather than mAh, because total energy between battery types is more similar, and PowerGenix says that's a more apples-to-apples comparison. That's debatable, from either side. It's true that the total energy is the same, but again, if the device being used doesn't limit the voltage, the device will use the extra voltage and the NiZn will spend its energy faster, so the NiZn's will provide less runtime. (And if the device *does* limit the voltage, then there's no advantage to using NiZn's in the first place, because the only reason you'd use them instead of NiMH's is if you needed the extra voltage to begin with.)

Voltage. NiZn's have the highest voltage of any rechargeable battery. The nominal voltage is 1.65, which is even higher than the 1.5V of alkalines. And fresh out of the charger, the initial voltage is as high as 1.85V. (PowerGenix, PDF) The higher voltage can be both a blessing and a curse. The upside is that flashlights burn brighter, and battery life will generally be longer in high-drain devices. (Some LED lights limit the voltage, so in that case NiZn's won't be brighter than 1.5 alkalines, but they'll still be brighter than 1.2V NiMH's.)

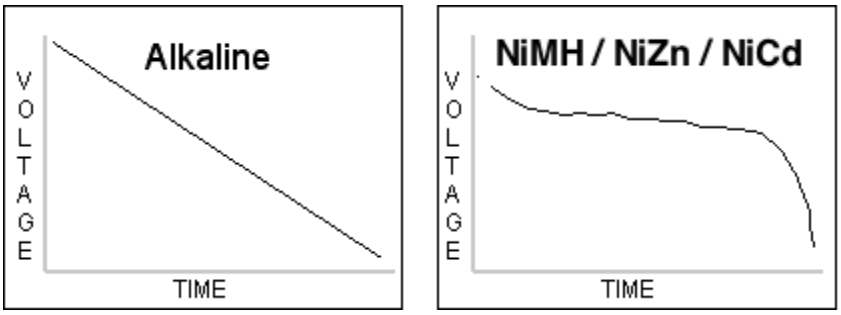
But there are downsides to the extra voltage. For lights, the brighter light means that the bulbs will burn out faster, sometimes immediately. (Tom's Guide) For cameras, a rapid flash cycle can fry the flash. (Amazon review) For electronics, first understand that some devices have a voltage regulator (which limits the max voltage coming from the batteries) or a voltage protector (which shuts off the device if the battery input is too high). If your device doesn't have one of these, and the device is very sensitive to voltage, then the batteries might fry it. It's hard to know whether a particular device is a "fry", "auto shut-off", or "no problem" variety. (Good luck.) The fewer batteries your device takes, the less likely you are to have a problem. A one-batery device is the least dangerous, two-batteries are a little more so, four batteries even more, and with 8+

batteries you're just asking for trouble. Powergenix mostly ignores this problem in their marketing materials, so shame on them.

If you're worried that NiZn's could be too hot for your device, then NiMH would be a better bet. If NiMH doesn't supply enough voltage for your device, you can mix NiMH and NiZn together, after seeing the caution about mixing NiMH and NiZn in the same device.

Self-Discharge. Powergenix claims a self-discharge rate of 8% per month, but NLee the Engineer's tests showed 13% per month, and I'm inclined to trust him.

NiZn's have a pretty high self-discharge rate, about 13% per month. (NLee the Engineer) This means they lose their charge by just sitting around, unused. Unlike NiMH's, there is no low self-discharge version available. If you use up and recharge your batteries quickly this won't matter to you. But if you need longer shelf life, you'll want to consider a LSD NiMH instead.



Voltage Drop. Like most other rechargeables, NiZn batteries maintain most of their voltage over the whole charge and then suddenly plummet. This contrasts to alkalines, which lose their capacity steadily. For this reason many electronic devices that tell you how much battery life is left have a hard time reporting an accurate level for rechargeables, but this is especially true for NiZn's, because their voltage is so high.

Charging. You need a *special* NiZn charger for these cells. *NiMH chargers will not work!* (See below for those who insist trying anyway.) PowerGenix makes two chargers: the white charger is smart and manages each cell separately, but there's only one status LED and it doesn't light up until *all* the batteries are done. (If one cell is bad, the red charge light will blink. Then you get to play musical batteries figuring out which one is bad.) The black charger requires charging in pairs, and doesn't manage the

batteries separately. Never buy a charger like that. There are also no-name or off-brand NiZn chargers available from China on eBay.

The white charger is labeled a "1-hour charger", but what that really means is that the batteries mostly full after an hour, but not completely. Powergenix says it takes about 1.5 hours to charge 1-2 AA's, and 2.5 hours to charge 3-4 AA's.

Unlike NiMH's, NiZn's tolerate fast-charging well. The PowerGenix spec sheet suggests a rate of between C/2 to C is okay (30 minutes to 1 hour).

Charging NiZn's in a NiMH charger. It's theoretically possible to charge NiZn's with a NiMH charger, but there are at least three problems. First, even a smart NiMH charger probably won't know when to stop charging NiZN's, and will overcharge, damaging the battery. Overcharging is harder on NiZn's than NiMHs. Second, how will *you* know when to stop charging? Armed with PowerGenix's recharge profile chart (PDF) and the battery and charger specs you could make a guess. (Good luck.) Finally, the charging profile of a NiZn is different from a NiMH. A NiZN should get less and less charging current as it approaches fullness, but NiMH chargers don't do that. The top-of-the-line La Crosse BC-series NiMH chargers put a minimum of 200mA into the batteries, for example, while the NiZn's should get only about 100mA near the end of the charge. I don't know the penalty for feeding more current than is recommended, but a shorter cycle life is my guess. Again here's PowerGenix's recharge profile chart (PDF). All that said, in a pinch, I've used my La Crosse BC-700 to slightly recharge NiZn's while traveling when I forgot to pack my NiZn charger, but I've terminated the charge well before the cells could be overcharged. When you put the cells in the BC charger they'll read "FULL" if their voltage is over ~1.3 volts, so I overrode that by pressing the cell button and then the Mode button to switch to charging mode. I monitored the voltage and took them out when they hit 1.8V, although you should be safe by going up to 1.9V. Even so, at that point your batteries will likely be only about half full. Anyway, all this is at your own risk, of course.

Discharged Voltage. The PowerGenix site provides absolutely no guidance as to how far NiZn's should be drained before charging to maximize capacity and cycle life. (Shame on them.) The typical discharge level for rechargeable batteries is 1.0 to 1.1V, and 1.1V is when I try to recharge my batteries (both NiMH and NiZn). The charger

won't recognize them at <0.5V, but even though the charger will recognize a 0.6V cell, its capacity or reliability might be greatly reduced if you drain your cells to that level.

Problems with the charger. NLee says that the charger stops charging when the voltage hits 1.9V, but if the battery is damaged and can't reach 1.9V, the charger will just keep charging and ruin the battery. That's not my experience: I had a damaged cell that showed as full at only 1.16V.

NLee also says that batteries left in an unplugged charger will drain 10-100 times faster than batteries left in other chargers, which means that they'll be discharged after only ten days.

Cycle Life. PowerGenix claims 100-500 cycles for their NiZn's, compared to 100-800 for NiMH and NiCd, but they don't specify the depth of discharge. NLee the Engineer says he found technical data on Powergenix's site that says that their NiZn's get only 200 deep-charge cycles, but I couldn't find any such data (probably no longer there). NLee's tests suggest a 50% capacity drop after only 100 cycles. I'm currently running my own tests, and it does look like cycle life is indeed pretty lousy.

Recycling. NiZn's are recycled in the same programs that take NiMH's and NiCd's. When your battery no longer holds a charge or its capacity is no longer useful, you can easily recycle it at over 30,000 locations in U.S. & Canada such as Sears, Office Depot, Home Depot, Target, Wal-Mart, Best Buy, and others. Find the nearest location to you from **RBRC** or Earth911.

Possible voltage problem with NiMH batteries

NiMH batteries put out less voltage than their alkaline counterparts (1.2V vs. 1.5V). Usually the difference doesn't matter, but sometimes it can. If a device really wants a lot of voltage then supplying it with less means you'll get much less runtime. Many devices, like digital cameras, are actually designed for the lower voltage of NiMH's so those devices are never a problem. But for other devices, the more batteries your device uses, the greater the risk that the voltage will be too low. For example, with devices that take...

- **1 battery.** The 0.3V difference between 1.5V and 1.2V is rarely a problem.
- **2 batteries.** Now the device expects 3.0V from alkalines but you give it only 2.4V from NiMH. The 0.6V is more likely to be a problem than it would be in a 1-battery device, but you're still probably fine.

- **3 batteries.** Now the differences are much more likely to manifest. I have lots of headband flashlights, and they're noticably dimmer and give less runtime with the 3.6V provided by the NiMH vs. the 4.5V that they're expecting from alkalines. Unfortunately there are few headlamps designed with NiMHs in mind, but both the **Zebralight** and the **Fenix HL21** take a single AA and are super-bright. I have one of each, and I love them. (Here's a comparison of the various Zebralight models.)
- **4 batteries.** Now we're looking at a 6.0 - 4.8V = 1.2V difference. That's pretty sizable, and I'm not surprised by poorer performance at this point.
- **6-8 batteries.** You will almost certainly have problems here. Giving 9.6V when the device is expecting 12V is just asking for poor performance.

So how do you deal with this? One solution is to use NiZN batteries instead, since they're rechargeable like NiMH, but they have plenty of voltage, 1.65V. Then of course you run into the opposite problem: NiZn are so powerful that they can fry sensitive devices, and that problem increases the more batteries the device takes. My own solution is to mix NiMH and NiZn in devices that take 3+ batteries. For example, 2 NiZn's @ 1.65V and 1 NiMH @ 1.2V = 4.5, exactly what I'd get from alkalines. However...

If you're not careful about mixing NiZn and NiMH together, you can easily kill your NiZn's. Your NiZn's will usually run out faster when you mix them with NiMH's, and if you don't stop and charge the NiZn's soon enough, the NiZn's will be damaged or dead. The solution here is to either make sure that all the mixed batteries have a similar mAh capacity (not mWh), or else be really diligent about monitoring the voltage of your NiZn's, charging them well before they get down to 0.5V (preferably charging when they drop to around 1.0-1.1V). As to the former (matching mAh capacity), that means you'll have to find and use lower-capacity NiMH's, because most NiMH's have a larger mAh capacity than NiZn's.

You might think you have to match only mWh and not mAh, because mWh is the total energy. That would be convenient, because mWh for common NiZn's and NiMH's is similar. But you really do have to match mAh, not mWh. The reason is that in devices which don't limit the voltage to about 1.2V, they'll make use of the NiZns' extra voltage. For example, the light will burn brighter, or the toothbrush will spin faster. So even if the

total energy expended between both kinds of batteries is the same, the NiZn expends it faster, because it's running at a higher rate. Another way to look at it is that, as NLee points out, the same amount of current (amps) flows through both batteries, regardless of what the voltage is. So if the device is drawing 350 mA (or whatever) from each battery, then the device with the fewer mAh is going to run out faster. That's usually going to be the NiZn.

Another solution to the problem of insufficient voltage from NiMH batteries is to make a power pack. If your device has an input for an AC/DC adapter, you can get battery holders from Radio Shack for just a few bucks, and wire them together (red wire to black wire), then attach a power plug so you can plug it into your device. If that doesn't make sense, just go into Radio Shack with your device, tell them you want to make a battery pack with battery holders for it, and ask them what you need. Be sure to tell them you'll be using 1.2V NiMH batteries and that you want to use an extra battery or two to get the right voltage. For example, if your device expects 6V and takes 4 batteries, then you'd actually use *five* batteries, because 5 x 1.2V = 6.0V.

Milking every last drop out of your alkalines

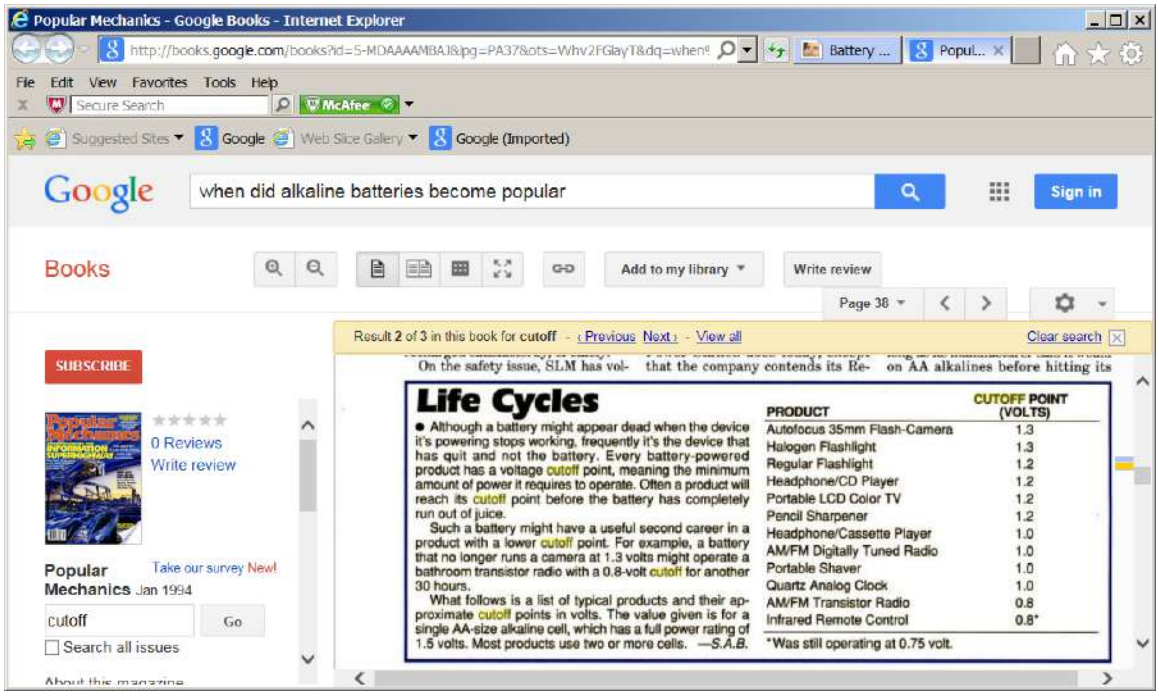
For most purposes you should be using NiMH instead of alkalines, but if you have some alkalines for whatever reason, these tips will help you get all the energy available from them.

Different devices stop working at different low voltage levels (the "cutoff voltage"). It could be 1.3V in a halogen flashlight, but only 1.0V in a clock or 0.8V in a radio or remote control. The tip here is that if your alkaline has "died" in a high-demand device like a flashlight, it could have a second life in a lower-demand device like a remote control or a clock. (Popular Mechanics has a table of cutoff voltages.)

Also, you can make a battery pack with a battery holder from Radio Shack or Amazon to milk your alkalines completely. For example, I have some battery-powered Christmas lights that expect 4.5V (three 1.5V AA's). I have some alkaline AA's that are around 1.15V. (I don't buy alkalines, I salvaged these from elsewhere.) Three of them would be only 3 x 1.15V = 3.45V, which would be kind of weak for the lights. But putting four of them in a battery pack gives me 4 x 1.15V = 4.6V, which is just about perfect.

Alkaline voltage drops sharply after hitting 0.9V, so consider a 0.9V alkaline as completely dead and useless.

http://michaelbluejay.com/batteries/tips.html#mixNiMHNiZn



Your guide to types of household batteries (AAA, AA, C, D, and 9V sizes)

Which kind of battery is best for which purpose?

	Rechargeable				*Disposable*			
	Nickel-Metal Hydride (NiMH)	LSD NiMH (low self discharge)	Nickel-Zinc (NiZn)	Rechargeable Alkaline	Alkaline	High-Drain Alkaline	Lithium (not lithium ion)	Carbon Zinc, Zinc Chloride *"General Purpose" "Heavy Duty"*
Summary	**Good for most uses,** except where you need	**Good for most uses,** including needing long shelf life.	**Good for devices which benefit from extra voltage** (e.g. digital cameras),	**Longest shelf life of any chargeable,** so it's good when batteries aren't replaced often, e.g.	**Cheap, widely available, but usually can't be recharged, and can**	**Not recommended for most uses. If you've got a high-drain device, a rechargeable**	**Powerful, but can't be charged,** and small risk of explosion. NiMH or	**Cheapest & least powerful.** Good only for low-drain devices like clocks

	long shelf-life.		but the high voltage could burn out lights & fry electronics. Also, very short cycle life.	clocks & radios. But capacity drops each cycle, and prone to leaking.	**leak.** Good for low-drain devices.	**is probably better,** so you don't have to keep buying batteries.	HD Alkaline are usually better. Great in smoke detectors: Ultralife brand lasts up to 7 years.	and remote controls.
Use is for Digital Camera or other high-drain device						(These 2 are okay, but since cameras go through batteries fast, you're better off with a rechargeable battery that you can reuse.)		
You go through batteries quickly								
You want more than 50 deep-discharge cycles (i.e., you fully use up the battery before charging)								
Use is for low-drain devices (clocks, remote controls, blinky lights)								
You want the brightest light from your flashlights or headlamps	see note 1		see note 2					
You're worried that excess								

voltage could fry your device								
Long shelf-life (i.e., want the battery to hold a charge after months of non-use)								
You don't want to risk a battery leaking in your device								
You want to use the C or D size ?				Rare; see sources				
For use in smoke detectors								
You want the cheapest battery and don't care how long it lasts								
Need to use in cold temperatures	Works well down to -4° to 14°F, depending on brand.			Performance often noticably worse below even 60°F, depending on brand/variety and rate of discharge..				unknown, but who cares?
Want to recycle them when they're dead	Over 30,000 locations in U.S. & Canada such as Sears, Office Depot, Home Depot, Target, Wal-Mart, Best Buy, and others (find nearest)			Drop-off recycling for these kinds of batteries is nearly non-existent. You generally have to mail in your batteries to recycle them.				

Which battery should I use?

To make it simple, you can just use **Imedion** LSD NiMH's by Powerex, which are good for just about any purpose.

For smoke detectors, use either the Lithium brands that are marked "7-year" or "10-year", or if you want a rechargeable, see my 9v batteries page for more details.

For low-drain devices like clocks, alkalines are acceptable, since they'll last a long time in clocks, so their lack of recharging ability isn't such a big downside (although personally I still use LSD NiMH for that application).

Which* brand *of battery is best?

NiMH: Powerex Imedion; beware of off-brand batteries

My favorite AA is the Imedion by Powerex. It's a good balance of capacity (2400 mAh), charge cycles (500), and low self-discharge rate (retains 85% after one year). The only downside is that they're slightly larger than regular AA's, so they might not fit in your device. If they don't, then my next recommendation is eneloop XX (similar to Imedion but a little pricier), or regular eneloops, which are cheaper but have only 2000 mAh.

That's the summary, but I have a whole page on NiMH battery brands (including a snazzy table comparing all the flavors of eneloops).

ALKALINES: Anything

You won't get lots better performance by buying one company's alkaline battery over another. "But what about the Energizer Bunny?!" you cry. Well, it makes a good commercial, but capacity is pretty similar from one alkaline maker to the next, according to the findings of Consumer Reports, ZBattery.com, and Lauri Nieminen. But alkalines are probably the wrong battery for the job anyway. For most uses you're better off with NiMH rechargeables, since the charging ability means you can stop buying batteries, and because NiMH's work better in high-drain devices like digital cameras anyway.

Household Battery Types Compared (AAA, AA, C, D, and 9V)							
	Rechargeable				*Disposable*		
	Nickel-Metal Hydride (NiMH)	**Nickel-Zinc (NiZn)**	**Nickel-Cadmium (NiCd)**	**Rechargeable Alkaline**	**Alkaline**	**Lithium**	**Carbon Zinc, Zinc Chloride** *"General*

							Purpose" "Heavy Duty"
The Basics							
Summary	**Good for most uses.**	**Good for devices which benefit from extra voltage** (e.g. digital cameras), but the high voltage could burn out lights & fry electronics. Also, possible reliability problems. Requires special charger.	**Obsolete.** Low capacity and toxc. Go with NiMH or NiZn instead.	**Lowest self-discharge of any recharge able,** making it good for devices where batteries are replaced infrequentl y, like clocks and radios. But the capacity drops every time it's charged, and prone to leaking.	**Cheap, widely availabl e, but usually can't be recharg ed, and can leak.** Good for low-drain devices.	**Power ful, but can't be charg ed,** and small risk of explosi on. NiMH or HD Alkalin e are usually better. Great in smoke detect ors: Ultralif e brand lasts up to 7 years.	**The cheapest (and least powerful) batteries available.** Good only for low-drain devices like clocks and remote controls.
Sample Brands	**Low Self Discharg e:** eneloop, Tenergy, Duracell, Kodak (rebrande d GP Recyko), Rayovac **Non-LSD:** Sanyo/ Panasoni	PowerGen ix (the only name-brand), but discontinu ed anyway. Generics are available on eBay	Golden Power (NiCd is obsolete.)	Juice, Pure Energy, Lenmar Chargeabl es, Accucell (just these 4)	**Normal:** Energize r, Rayovac **High-Drain:** Energize r e2 Titanium, Kodak Photolife, Duracell Ultra	Energi zer Ultimat e Lithium , Energi zer Advan ced Lithium	usually a no-name brand

	c, Duracell						
Where to Recycle	Over 30,000 locations in U.S. & Canada such as Sears, Office Depot, Home Depot, Target, Wal-Mart, Best Buy, and others (find nearest)			Drop-off recycling for these kinds of batteries is nearly non-existent. You generally have to mail in your batteries to recycle them.			
Other important info							
Capacity	**High**	**High**	Low	**High** at first but less each cycle	**High**	**High**	Low
Performance in high-drain devices (e.g., digital cameras)	**Very Good** 1.8x more pix than standard alkalines	**Excellent**	Poor (because capacity is low)	Poor	STANDARD: Poor HI-DRAIN: Good 1.4-2.5x more pix than standard	**Excellent** 3-13x more pix than standard Alkalines	Super Poor
Self-discharge rate (calendar life if not used)	**LSD NiMH:** Slow-Medium (retains 75% after 1, 2, or 3 years depending on brand) **Non-LSD NiMH:** Fast (loses 15%/mo)	Fast (loses 13%/mo.)	Fast (loses 10% in 1st 24hrs, then 10%/mo.)	**Very Slow** (<0.5%/mo.; shelf life 5-7 years)	**Very slow** (retains 80% capacity after 5-7 years)	**Very slow** (loses 0.6% per year; 7-15 year shelf life)	**Slow** (retains 80% capacity after 3-4 years)
% of capacity avail. when used at freezing temps (0°C), instead of room temp.	91%	(researching...)	(researching...)	35-75% (more capacity lost at higher drain rates)	31-75% (more capacity lost at higher drain rates)	82-98% (more capacity retained at lower drains)	100%

Temperature range (use)	-4F°-122° F (0°-50° C)	-4° to 140° F (-20° to 60° C)	-22° to 140°F (-30° to 60°C)	-4° to 140°F (-20° to 60°C)	0-131°F (-18° to 55°C)	-40° to 140°F (-40° to 60°C)	0° to 130°F (-18° to 55°C)
Self-discharge is slowed by freezing or refrigeration?	**Yes** (10% loss after several months)	(researching...)	(researching...)	No, and doesn't matterâ€"long shelf life already	Not really, and doesn't matter -- long shelf life already	Doesn't matter -- long shelf life already	Doesn't matter -- long shelf life already
	Nickel-Metal Hydride (NiMH)	**Nickel-Zinc (NiZn)**	**Nickel-Cadmium (NiCd)**	**Rechargeable Alkaline**	**Alkaline**	**Lithium**	**Carbon Zinc, Zinc Chloride** *"General Purpose" "Heavy Duty"*
Capacities. Comparing mAh/mWh specs isn't really an apples-to-apples comparison because real-world performance differs. See "Performance" above for a better idea.							
Capacity (AAA) *varies by brand*	Normal: 750-1200mAh LSD: 800 mAh	700 mAh	300-800 mAh	800 mAh	1077 mAh	1100-1250 mAh	325-550 mAh
Capacity (AA)	Normal:1200-2700 mAh LSD: 2000 mAh	1350-1500 mAh but capacity drops sharply as cells are cycled	600-1000 mAh	1440-2000 mAh but drops each cycle	2400 mAh	2100-3000 mAh	500-1100 mAh
Capacity (D)	2200-12,000 mAh eneloop C & D available only in Japan	not made in this size	1800-5000 mAh	8000 mAh at first	13,875 mAh	not available in this size	3000-6880 mAh
Recharging							
Rechargeable?	**Yes**	**Yes**	**Yes**	**Sort of***	Not really	No	No

Recharge cycles (deep)	Normal: 100-1000 LSD: 500-1500	100-800, claimed ~10, my opinion	500-2500	25-100 *with less capacity each time*	<10	N/A	N/A
Memory effect	No	No	No, but overcharging reduces capacity	No	No	N/A	N/A
Miscellaneous							
Initial Voltage	1.2 V	1.65 V (1.85 at first)	1.2 V	1.5 V	1.5 V	1.5-1.8 or 3.6 V	1.5 V
Weight (AA)	30g	25g	22g	22g	23g	14.5g	Heavy Duty: 15g
Commonly available since...	Non-LSD: ~2000 LSD: 2005	2009	(researching...)	1994	1960's	1990's	(researching...)
Sample spec sheets	Energizer AA	(researching...)	(researching...)	Juice	Energzer AA: Regular, High-Drain,	Energizer Ultimate Lithium,	Eveready AA (HD)
Typical price for 4 AA	$8.22	$16.50	$5.97	$6.00	$3.78	$9.97	$1.29

Notes on the Table:

Lithium-ion. Lithium-ion is another kind of rechargeable but it doesn't fit in the table, though it's not available in standard voltages anyway, except for 9V. See my Lithium-ion and 9V batteries sections for more.

Volts. The lower voltage of NiMH's & NiCD usually isn't a problem unless your device takes â‰¥4 batteries and it's not designed to take rechargeables. The higher voltage of NiZn and Lithium might fry your device, especially if your device takes â‰¥4 batteries, especially if it's designed to take 1.2V NiMH's or NiCD's instead of 1.5V alkalines. See the Battery TIps page.

Capacity. (1) Varies by brand. (2) Capacity is misleading because different kinds of batteries perform differently under different kinds of loads, so you can't compare the mWh ratings on a 1:1 basis. For example, a standard alkaline in a high-drain device will supply less than half of its rated capacity. (Energizer PDF, p. 5) (3) In general, higher drains mean less capacity (e.g., doubling the draw means *less* then half as much capacity). (4) Most figures are rounded.

Recharge cycles (aka "Cycle Life")**.** The number of times the battery can be deeply drained (down to around 1.0V) and then recharged, and still have at least 60% of its

original labeled capacity. NiMH upper limit from Sanyo eneloop specs.
Self-discharge rate. How quickly the batteries lose their charge just sitting around, unused. "LSD" refers to the "Low Self-Discharge" versions of NiMH, such as Sanyo eneloop. Percentage decline each month is in terms of the initial charge, not the remaining charge that month.
Prices. Pricing is from Home Depot 2012 except for Walmart for NiZn, and Sundance Solar and Rechargeable Alkaline. CheapBatteries.com may have cheaper pricing.
Sources. See my sources page.