

SAMPLE

Which alkaline battery last longer and is more cost efficient per hour: Duracell, Energizer, or Rayovac?

Table of Contents:

I.	Introduction		
	Purpose	pg.	3
	Research Paper	pgs.	4-7
	Hypothesis	pg.	8
II.	Experiment		
	Materials	pg.	9
	Procedure	pgs.	10
	Data	pgs.	10-16
III.	Conclusion		
	Analysis and Conclusion	pgs.	17-20
	Bibliography	pg.	21-22
	Abstract	pg.	23
	Acknowledgements	pg.	24

SAMPLE

**Purpose:**

The purpose of the project is to find which of the three major brand name batteries, Duracell, Energizer, and Rayovac is more cost efficient for consumers. Alkaline batteries are a multi million dollar industry in worldwide. If consumers are aware of which battery not only lasts longer, but is also more cost efficient, then consumers will be able to spend their hard earned money wisely. Additionally, young consumers with little funds should be aware of the best deal for an alkaline battery for electronic equipment such as CD players and alarm clocks.

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## Research Paper:

To determine which battery last longer, one is required to understand how batteries work. A battery or a “cell” is a device that contains two substances. Then chemical energy is converted to electrical energy. Components to a common battery include: a cathode or positive electrode; an anode or negative electrode, and an electrolyte, usually in a liquid solution. The electrolyte permits the transfer of ions from the anode to the cathode and vice versa. If one connects a wire between the negative and positive terminals, the electrons will flow from the negative to the positive terminals as fast as they can which causes the battery to wear out. This reaction can be dangerous, especially with large batteries. Normally, a load such as light bulb, motor, and an electronic circuit like a radio is connected to the battery using a wire.

The first battery was created by Alessandro Volta in 1800. Volta created a battery by making a stack of alternating layers of zinc, blotting papers soaked in salt water and silver. His arrangement was known as a voltaic pile. The voltage can be increased by increasing the layers. Modern batteries use a variety of chemicals to power their reactions. An alkaline battery use zinc and manganese oxide for the electrodes with an alkaline electrolyte. In many devices that use batteries, such as radios and flashlights, you would not just use one cell at a time. The batteries are grouped together to form higher voltages, or in a parallel to form higher currents. In a serial or parallel arrangement, the current add up. If you assume that a cell produces 1.5 volts, then four batteries in parallel will also produce 1.5 volts, but the current supplied would be four times that of a single cell ( if using 4 batteries). The four voltages add together to produce 6 volts. When you buy a pack of batteries, the package will tell you the voltage and current rating. For

example, a digital camera might use four nickel-cadmium batteries that are rated at 1.25 volts and 500 milliamp-hours for each cell. The milliamp-hour means that the cell can produce 500 milliamps for one hour. Batteries, though, are not that linear. For one thing, all batteries have a maximum current that they can produce. Additionally, at higher current levels, batteries can produce a lot of heat which wastes some of their power. Using the amp-hour rating on the package, you can roughly estimate how long the battery will last under a given load.

Today, batteries are a multi million dollar industry in the United States. For consumers, picking the right battery for the right task is very confusing, even for those who understand how batteries work. Therefore, how does one choose the very best battery? First, determine the type of application. There are two major types-high drain and low drain. High drain devices include MP3 players or boom boxes. Low drain devices include desk alarm clocks and wall clocks. Secondly, determine the right battery. Lithium and some alkaline batteries are designed for high drain devices. Heavy duty alkaline batteries are used for low drain devices. Thirdly, determine the use by date. The freshest alkaline batteries have an expired date of no less than five years. Expired batteries have about 85% of their fresh capacity. Finally, choosing a brand is the most difficult for consumers. Duracell, Energizer, and Rayovac have flooded the market with advertising claims. Energizer states that their batteries will keep going, going, and going. Most are familiar with the Energizer bunny mascot. In fact, the Energizer bunny has become slang meaning one with abundant energy. Duracell claims that their packed battery will last longer. Finally, Rayovac claims that their battery last 2 ½ times more than any other alkaline battery. Who is right? Independent studies are inconclusive.

What has been found is that certain alkaline batteries work better for different devices; however, which lasts longer has been tested quite frequently with different results. For example, Shan-Lyn Forsythe, a consumer for Zbattery.com, tested batteries using flashlights. The results were minimal. By a slight margin, the flashlight with the Energizer batteries was the first to extinguish the light. Ms. Forsythe did another experiment using clocks. The Energizer battery performed better in this experiment. Therefore, Zbattery.com concluded that for continuous non stop usage, use the Rayovac. For longer –life duration devices use Energizer. Zbattery.com did note that storing batteries in the refrigerator doubled their lifespan. Consumer Reports Magazine, using their independent laboratories rated the batteries based upon price, use in digital cameras and CD players, and the cost per hour. Performance for all brand name batteries was listed as poor using digital cameras as a device. Performance for all brand name batteries varied from very good to fair using CD players as the device. Costco batteries, Duracell CopperTop were listed as the best performers when the CD players using CD players as the device. Energizer Max and Rayovac were listed as good when using CD players as the device. When value is considered, though, Rayovac was listed as the best value with a cost of ten cents per hour. Duracell CopperTop and Energizer Max were each listed with a cost of 20 cents per hour.

What can consumers do to get the best battery for performance while at the same receiving a good value? Consumers need to remember that certain brand batteries perform better than others depending on the device. Consumers will have to trial and error on their devices and observe which battery result in a better performance. To receive the best value, consumers need to shop and compare prices in order to get the best

value. With regard to myths about batteries (i.e. storing them in a refrigerator or freezer), consumers need to remember that independent testing has shown little improvement and are inconclusive. Therefore, consumers should follow their personal preference when buying alkaline batteries for performance. For the best values, consumers should keep a keen eye out for prices to get the better deal for cost per hour of usage.

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**Hypothesis:**

**If Rayovac AAA, AA, A, and C, and D batteries are used in flashlights, kids' toys, CD players, and digital alarm clocks, then the Rayovac batteries will be more cost efficient than Energizer and Duracell AA, AAA, C, 9 Volt.**

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## Materials:

1- 16 pack package of AAA Duracell batteries  
1- 16 pack package of AAA Energizer batteries  
1- 12 pack package of AAA Rayovac batteries  
1-10 pack package of AA Duracell batteries  
1-10 pack package of AA Energizer batteries  
1-12 pack package of AA Rayovac batteries  
1 -8 pack package of C Duracell batteries  
1-8 pack package of C Energizer batteries  
1- 10 pack package of C Rayovac batteries  
1-2 pack package of 9 Volt Duracell batteries  
1-2 pack package of 9 Volt Energizer batteries  
1-2 pack package of 9 Volt Rayovac batteries  
3- Gel Grip Brinkman Flashlights from Target that take AA batteries  
1- T300-B TrueTech CD R/RW Player with AM/FM Stereo Radio that take C batteries.  
1—True tech Set Digital Alarm Clock (9 volt batteries) \*\*  
1- Rubriks Cube Game (AAA batteries)  
Clock/Watch  
Graph paper  
Computer (Microsoft Office)  
Ziploc Bags  
35 mm CVS Disposable Camera  
Markers  
Casio-fx 300 MS Scientific Calculator  
Construction Paper

## Procedure:

### Day One:

Purchase equipment at various stores and complete a price per unit spreadsheet on all of the batteries to see which battery is the best deal per unit.

### Day Two:

Place Duracell, Energizer, and Rayovac in each of the Flashlights. Turn all batteries on at the same time. Record and observe which battery last longer. Calculate which battery is the best deal per minute and per hour.

### Day Three:

Place Duracell batteries in the CD player. Play a CD until batteries run out. Repeat the procedure with the Rayovac and Energizer batteries. Record time each brand of battery lasted. Calculate which battery is the best deal per minute and per hour.

### Day Four:

Place Duracell battery in the alarm clock. When clock quits working, then change the batteries with Energizer, then Rayovac. Observe/chart which battery remains powered longer. Calculate which battery is the best deal per minute and per hour.

### Day Five:

Place Duracell battery into the Rubrics Cube game. Using room temperature (78 degrees Fahrenheit), play game until batteries expire. Change batteries. Record and chart results. Calculate which battery is the best deal per minute and per hour.

### Day Six:

Chart all the batteries and their deal per minute and per hour.

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**Data:**

<b>Size of Battery</b>	<b>Brand</b>	<b>Cost</b>	<b>Cost per Unit</b>
9 Volt	Duracell	2 for \$5.54	\$2.77
9 Volt	Energizer	2 for \$5.54	\$2.77
9 Volt	Rayovac	2 for \$5.54	\$2.77
AAA	Duracell	16 for \$9.59	\$0.60
AAA	Energizer	16 for \$9.59	\$0.60
AAA	Rayovac	12 for \$5.99	\$0.50
AA	Duracell	10 for \$6.99	\$0.70
AA	Energizer	10 for \$6.99	\$0.70
AA	Rayovac	12 for \$5.99	\$.50
C	Duracell	8 for \$9.29	\$1.16
C	Energizer	8 for 9.59	\$1.20
C	Rayovac	10 for \$8.99	\$0.90

<b>CD PLAYER With C Batteries</b>	<b>Cost Per Battery</b>	<b>Elapsed Time for Each Battery</b>	<b>Cost Per Battery Per Hour</b>
<b>Duracell</b>	<b>\$1.16</b>	<b>67 minutes</b>	<b>\$1.20</b>
<b>Energizer</b>	<b>\$1.20</b>	<b>180 minutes</b>	<b>\$0.60</b>
<b>Rayovac</b>	<b>\$0.90</b>	<b>82.5 minutes</b>	<b>\$.60</b>

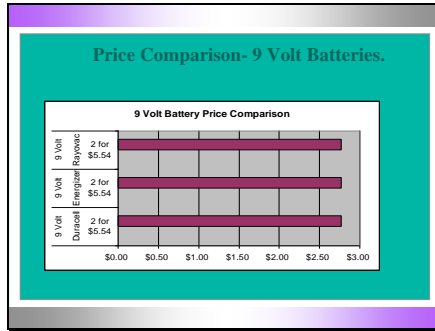
<b>Rubriks Cube With AAA Batteries</b>	<b>Cost Per Battery</b>	<b>Elapsed Time for Each Battery</b>	<b>Cost Per Battery Per Hour</b>
<b>Duracell</b>	<b>\$.60</b>	<b>391 minutes</b>	<b>\$0.12</b>
<b>Energizer</b>	<b>\$1.20</b>	<b>120 minutes</b>	<b>\$0.20</b>
<b>Rayovac</b>	<b>\$0.90</b>	<b>373 minutes</b>	<b>\$0.14</b>

<b>Alarm Clock with the 9 Volt Battery</b>	<b>Cost Per Battery</b>	<b>Elapsed Time for Each Battery</b>	<b>Cost Per Battery Per Hour</b>
<b>Duracell</b>	<b>\$2.77</b>	<b>3402 minutes</b>	<b>\$0.05</b>
<b>Energizer</b>	<b>\$2.77</b>	<b>1999 minutes</b>	<b>\$0.08</b>
<b>Rayovac</b>	<b>\$2.77</b>	<b>2886 minutes</b>	<b>\$0.06</b>

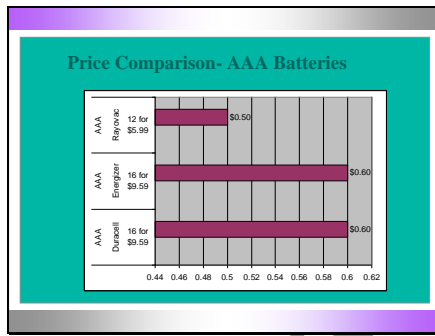
<b>Flashlights With the AA Battery</b>	<b>Cost Per Battery</b>	<b>Elapsed Time for Each Battery</b>	<b>Cost Per Battery Per Hour</b>
<b>Duracell</b>	<b>\$0.70</b>	<b>1231.50 minutes</b>	<b>\$0.03</b>
<b>Energizer</b>	<b>\$0.70</b>	<b>1350 minutes</b>	<b>\$0.03</b>
<b>Rayovac</b>	<b>\$0.50</b>	<b>1354 minutes</b>	<b>\$0.02</b>

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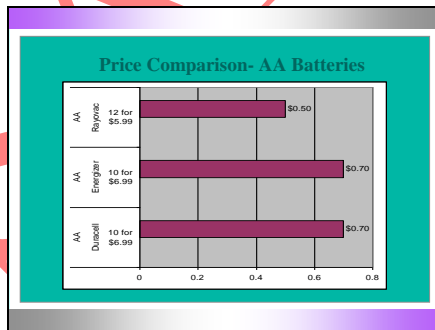
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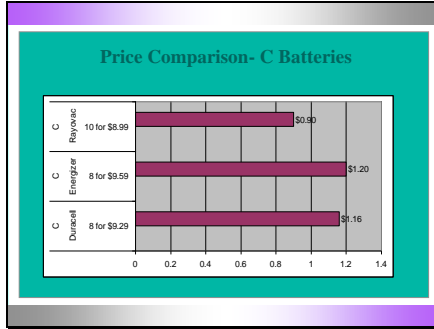
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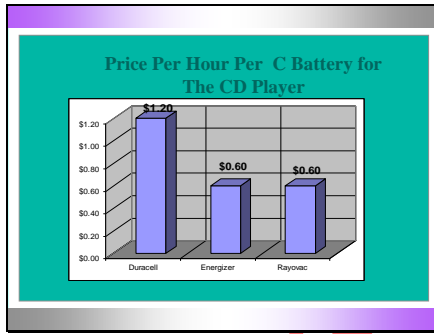
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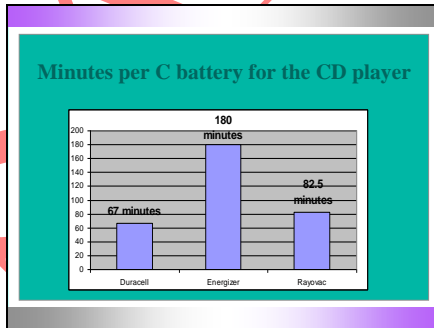
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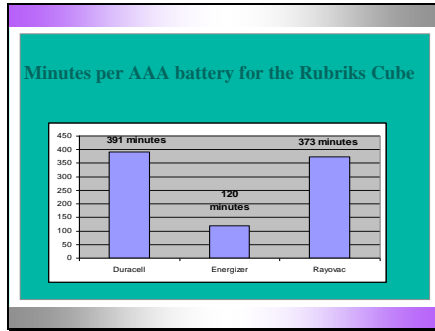
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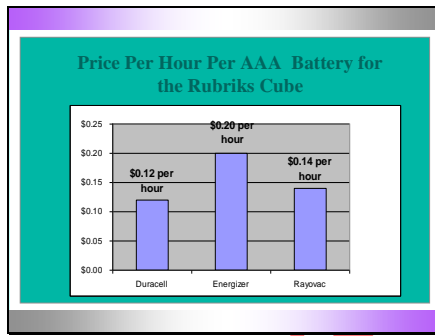
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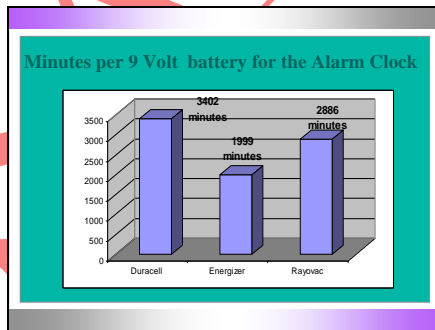
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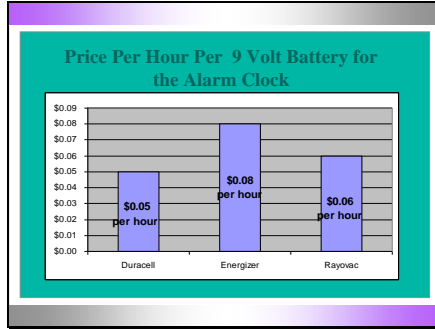
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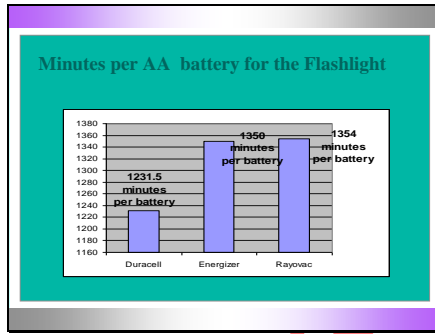
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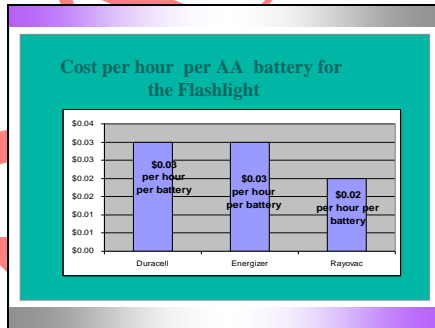
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## Analysis and Conclusion

Does which brand of alkaline battery matter as far as cost and performance? For costs, overall Rayovac is the cheaper brand. This is true for the AAA batteries by \$.10 per unit, the AA batteries by \$0.20 per unit, and the C batteries by \$0.30 per unit. On the contrary, all the brands for the 9 Volt batteries cost the same at \$2.77 per unit.

**Table 1: Cost of battery per unit**

Size of Battery	Brand	Cost	Cost per Unit
9 Volt	Duracell	2 for \$5.54	\$2.77
9 Volt	Energizer	2 for \$5.54	\$2.77
9 Volt	Rayovac	2 for \$5.54	\$2.77
AAA	Duracell	16 for \$9.59	\$0.60
AAA	Energizer	16 for \$9.59	\$0.60
AAA	Rayovac	12 for \$5.99	\$0.50
AA	Duracell	10 for \$6.99	\$0.70
AA	Energizer	10 for \$6.99	\$0.70
AA	Rayovac	12 for \$5.99	\$.50
C	Duracell	8 for \$9.29	\$1.16
C	Energizer	8 for 9.59	\$1.20
C	Rayovac	10 for \$8.99	\$0.90

The question becomes: which battery is most cost effective for the consumer? The results were mixed. The digital alarm clock used 9 volt batteries. Duracell batteries lasted longer- 3402 minutes per battery vs. 1999 minutes for the Energizer batteries and 2886 for the Rayovac batteries. When cost per hour is calculated though, Duracell is the most cost effective, followed by Rayovac and Energizer. Since all the 9 volt batteries are the same price, consumers should find that the Duracell is the most cost effective.

**Table 2: 9 Volt Battery/Digital Alarm Clock**

<b>Alarm Clock with the 9 Volt Battery</b>	<b>Cost Per Battery</b>	<b>Elapsed Time for Each Battery</b>	<b>Cost Per Battery Per Hour</b>
Duracell	\$2.77	3402 minutes	\$0.05
Energizer	\$2.77	1999 minutes	\$0.08
Rayovac	\$2.77	2886 minutes	\$0.06

The C batteries using a CD Player also brought mixed results. The cheapest battery is by far the Rayovac battery. The Rayovac tied with Energizer for the most cost efficient per hour even though the battery ran approximately twice as less as the Energizer battery. If a consumer is looking for the longest running C battery, the choice would be the Energizer battery; however, the Rayovac is the best overall choice for cost efficiency.

**Table 3: C Batteries using a CD Player**

<b>CD PLAYER With C Batteries</b>	<b>Cost Per Battery</b>	<b>Elapsed Time for Each Battery</b>	<b>Cost Per Battery Per Hour</b>
Duracell	\$1.16	67 minutes	\$1.20
Energizer	\$1.20	180 minutes	\$0.60
Rayovac	\$0.90	82.5 minutes	\$.60

The results for the AAA batteries were clearer. The Duracell batteries were the cheapest and most cost efficient for the consumer when using a child's toy, Rubrik's cube.

Rayovac was the second best for the consumer for both price and cost efficiency per hour. Energizer was the most expensive and least cost effective.

**Table 4: AAA batteries using a Rubrik's Cube Game**

<b>Rubriks Cube With AAA Batteries</b>	<b>Cost Per Battery</b>	<b>Elapsed Time for Each Battery</b>	<b>Cost Per Battery Per Hour</b>
Duracell	\$0.60	391 minutes	\$0.12
Energizer	\$1.20	120 minutes	\$0.20
Rayovac	\$0.90	373 minutes	\$0.14

Using the AA battery in the flashlight, the findings for cost per battery and, cost per battery per hour, and longest lasting battery was Rayovac. Energizer and Duracell were tied for cost per battery per hour and cost per battery. Therefore, the best choice for a consumer for an AA battery is Rayovac.

**Table 5: AA batteries using a flashlight**

<b>Flashlights With the AA Battery</b>	<b>Cost Per Battery</b>	<b>Elapsed Time for Each Battery</b>	<b>Cost Per Battery Per Hour</b>
Duracell	\$0.70	1231.50 minutes	\$0.03
Energizer	\$0.70	1350 minutes	\$0.03
Rayovac	\$0.50	1354 minutes	\$0.02

Questions and difficulties did arise during this experiment. One, do consumers consider buying cheaper batteries when pennies are considered. For example, the data for AA batteries showed only a difference of one penny for cost of battery per one hour of use. The 9 volt battery also showed little difference in cost. Is a 3 cent differential a major difference for consumers? The most discrepant cost during this experiment was sixty cents for the C batteries. Advertisements and sales for consumers probably play

more of a role for consumers when buying batteries. Maybe the money that advertisers spend for batteries is worth the cost if consumers know that there is a little difference with the expenses.

Problems did come up with this experiment. The Rubriks toy, for the most part, wore out before the batteries did. The alarm clock data is skewed because the clock time and the actual time had major discrepancies after a few hours. If relying upon a battery for operating alarm clocks, most consumers would be unhappy. Using electricity for alarm clock is clearly more accurate. Finally, this experiment could be considered authentic due to the fact that the electronic equipment had to be turned off and on for daily living activities such as sleeping, eating, and going to school. If all equipment were run until the battery exhausted, maybe the results would be different.

To conclude, overall the longest lasting battery were the Duracell and Rayovac depending upon the battery. For the most cost efficient battery, Duracell and Rayovac were the best choice depending upon the battery. What does this all mean for consumers? For sure, Energizer is not as advertised and came in last for enduring power and cost with the exception of the C batteries. Should consumers, therefore, choose Duracell or Rayovac? Since the research reinforces this experiment with the fact that the results are inconclusive, consumers should use their own personal preference and consider the size of the battery and their purpose for their electronic equipment.

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## Abstract

Does brand name matter for batteries? Which battery is not only cheaper at checkout, but is also cheaper per unit per hour? Batteries are expensive as the total price for all the batteries in this experiment was \$89.63; however, the cost per battery ranged from \$0.50 to \$2.77 which is a difference of \$2.27. The cost, though, per hour, is relatively cheap. The range for cost per hour was \$0.05 to \$1.20. The cheapest battery for consumers is Rayovac for all sizes (AAA, AA, C and 9 volt). For the cheapest cost per hour, though, Duracell and Rayovac proved the best choice for consumers depending upon the battery and electronic equipment. Duracell is the best choice for AAA and 9 volt batteries, while Rayovac is the best choice for AA and C batteries. The experiment is considered authentic vs. experimental as electronic equipment was turned off and on for daily living activities, rather than leaving equipment continuously on until the batteries ran out. In life, equipment is used for consumer convenience, which varies by consumer. One can conclude that most consumers turn on and off electronic devices and the time is varied by consumer. For consumers, though, personal preference seems to be the most logical choice as the difference in overall cost and cost per hour is very little, as the research and this experiment conclusion's are mixed. Consumers should watch the price at their favorite stores to get the best price and follow manufactures directions for battery operation for their electronic device.

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