

The Economics of Minerals: Rechargeable Batteries and Mineral Resource Use

Learning objectives

By completing this activity and the homework, you will:

- Identify the mineral resources used in rechargeable batteries.
- Describe overall trends graphed for production and value (price) of nickel, cadmium, lithium, and lead, and identify changes in trends and/or anomalous features in the graphs.
- Explain trends, changes over time, and anomalies in terms of mine production, demand, recycling, changes in battery technology, regulation due primarily to health concerns, and/or population growth.
- Use a concept map to interpret the complex relationships among consumers, producers, regulating agencies, and the environment in a global context.
- Examine your own consumer behavior and judge the impacts of this behavior on sustainability.

Introduction

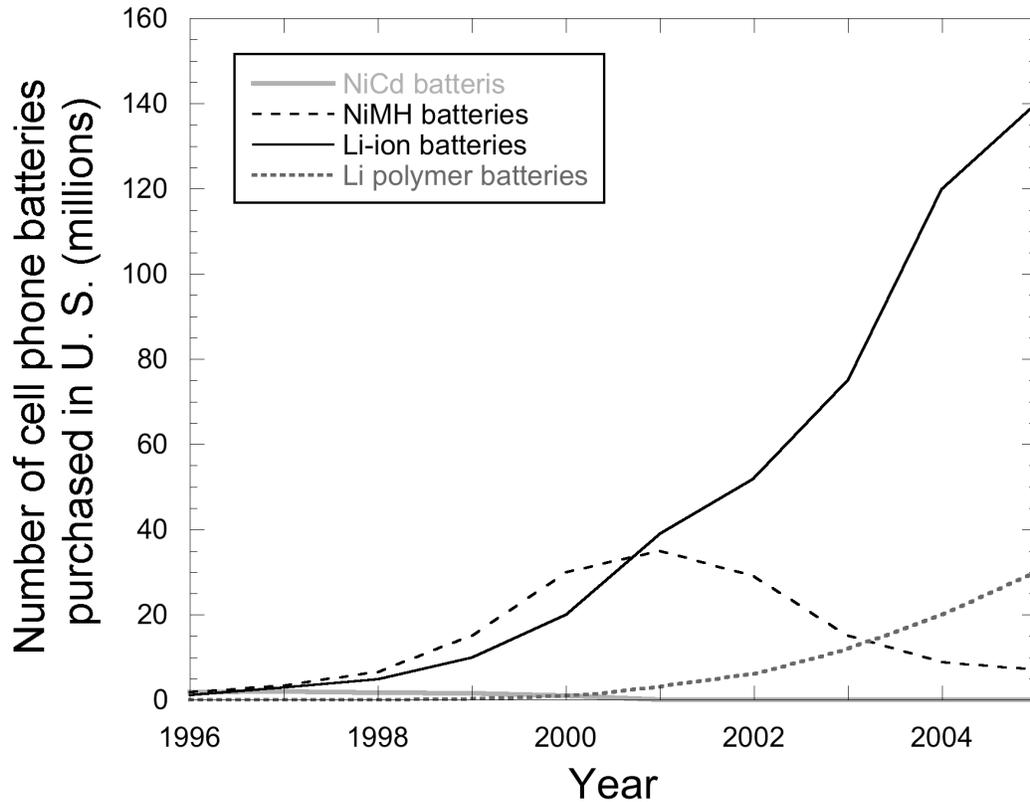
Mineral resources are important because they are used to make products. Thus consumers drive the quest for mineral resources, and economics play a large role in whether and how much minerals are mined.

In this activity, you will consider the mineral resources used to make rechargeable batteries, and the economic factors and consumer choices that influence the supplies of these mineral resources.

You need to know that there are five main types of rechargeable batteries: acid-lead, NiCd (nickel cadmium), NiMH (nickel metal hydride), Li-ion (lithium ion), and Li-polymer (lithium polymer).

Part 1A. Changing technology: cell phone batteries

In this part, we'll look specifically at batteries themselves. Use the graph below, which shows the number of cell phone batteries purchased annually in the United States, to answer questions 1–3.



1. Summarize in what ways the number of cell phone batteries has changed since 1996. You can write different answers for the different types of batteries.

2. Why do you think that the number of batteries used has changed?

3. The graph shows consumption of cell phone batteries in the United States. What do you think a graph showing global consumption would look like? Why?

Part 1B. Changing technology: car batteries

One important characteristic of batteries is their energy density. This tells how much energy (in Watt-hour) is contained in a given mass (kilogram). We want a battery that has a lot of energy for its size. Cost is another consideration. Safety is also a factor; we want batteries that do not cause laptops (or cars) to explode! The table shows energy densities and approximate costs of the different types of rechargeable batteries. Use the table to answer questions 4–8.

Rechargeable battery type	Energy density (Wh/kg)	Approximate battery cost
Lead-acid	30–50	\$25 (6 V)
NiCd	45–80	\$50 (7.2 V)
NiMH	60–120	\$60 (7.2 V)
Li-ion	110–160	\$100 (7.2 V)
Li-ion polymer	100–130	\$100 (7.2 V)

Standard car batteries are lead-acid batteries. Batteries in hybrid-electric and plug-in-electric cars are either NiMH (for example, in the Toyota Prius) or Li-ion (for example, in the Chevy Volt).

4. Why are the newer electric cars using Li-ion batteries?
5. Why are lead-acid batteries still used in gasoline-engine cars?
6. In what ways do you think demand for lead, lithium, and nickel will change in the future?

- Three new nickel mines/plants open in Australia: 1998–2004
- First commercial HEV (hybrid-electric car) introduced to U.S. market: 1999 (until 2008, all used NiMH batteries)
- Global recession December 2007–2009

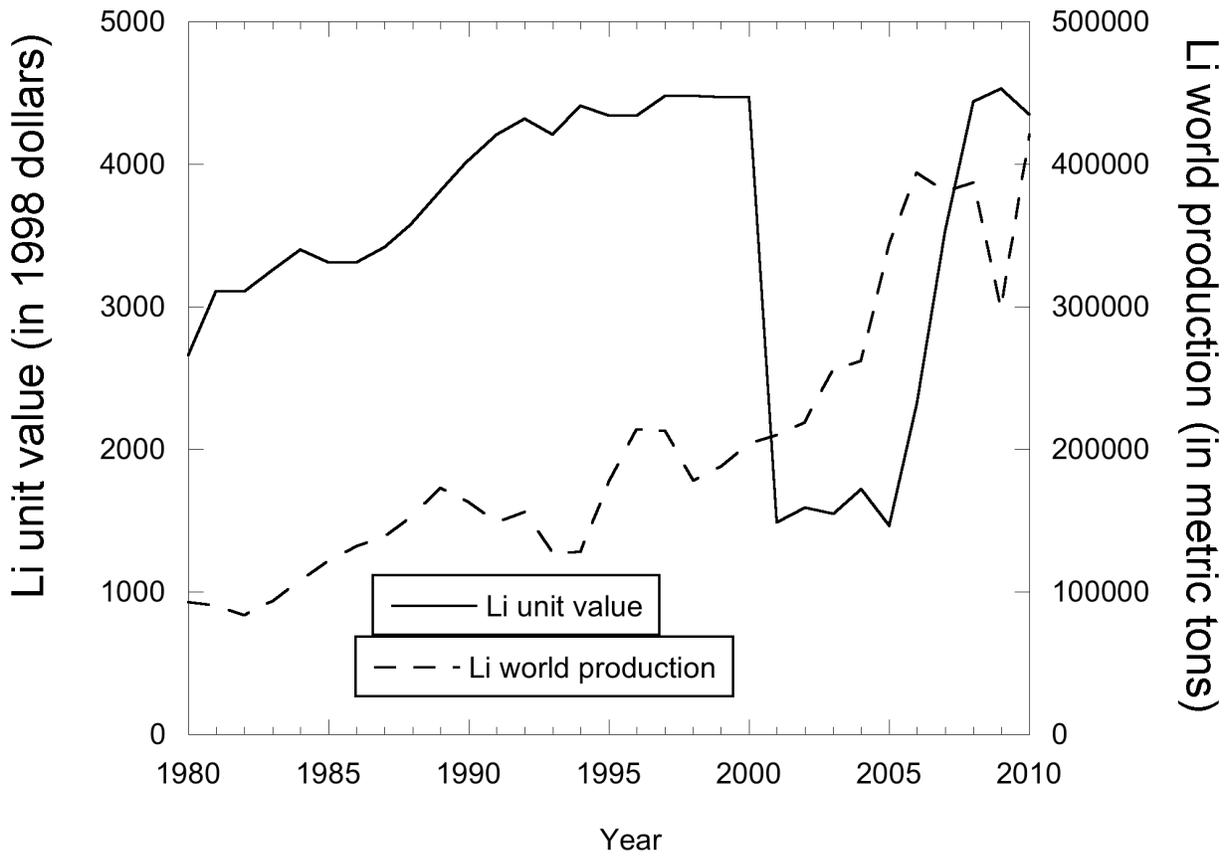
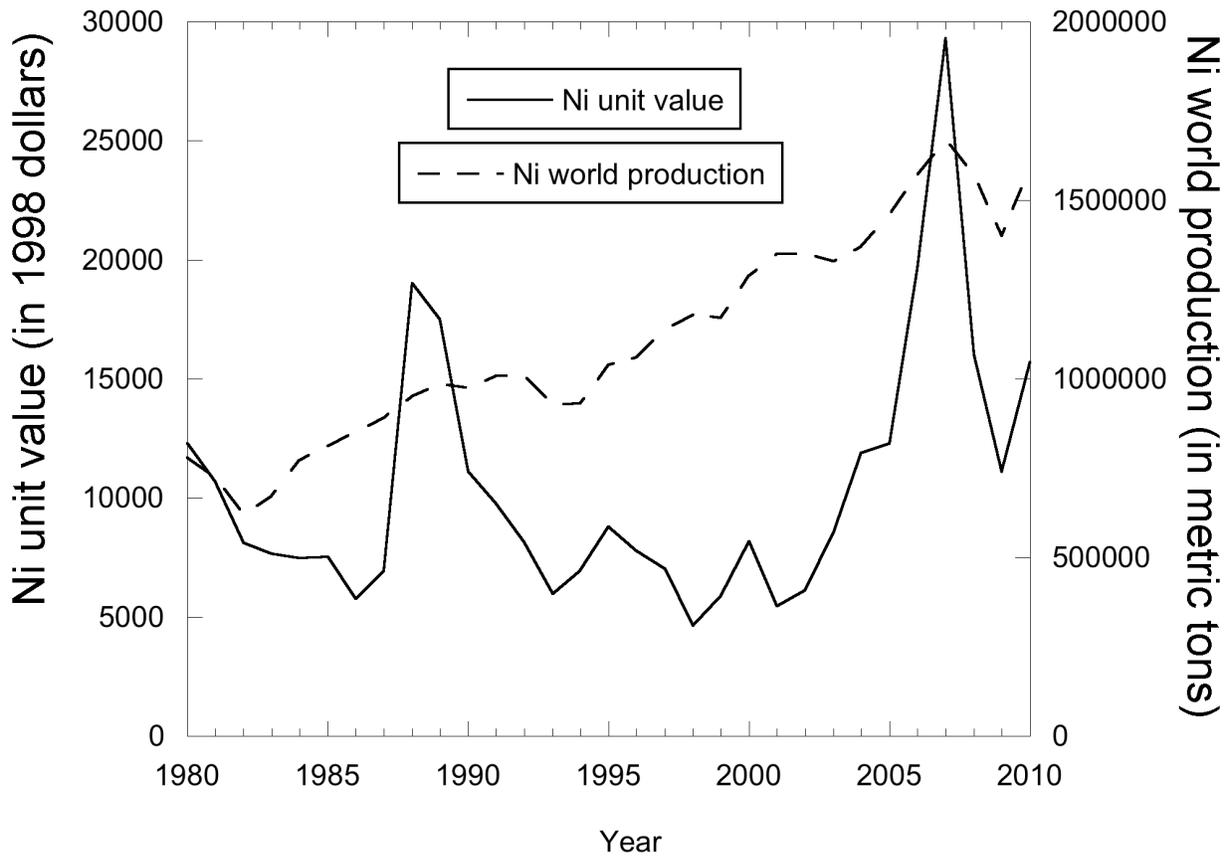
These other events also may have impacted either lithium or nickel demand, supply, and price:

- First NiMH batteries appeared in consumer goods: 1989
- Congress passes Mercury Containing and Rechargeable Battery Act (facilitates recycling of NiCd batteries): 1996
- Large exports of scrap metal (containing nickel) from Russia: 1996–1998
- Improvements in PAL processing technology (used for nickel): 2000
- American Recovery and Reinvestment Act—money spent on rechargeable battery technology (including opening a Nissan LEAF [electric car] plant in 2010): 2009
- First plug-in electric vehicles (LEAF, Volt: these use Li-ion batteries): 2010

Part 2B. Testing your predictions against data

Use the graphs of nickel (Ni) and lithium (Li) production (production = mining and recycling) and value (price) to answer this question. The values are given in price (in 1998 dollars, to remove effects of inflation) per metric ton.

10. Pick two predictions you made in #9. Explain how data presented in the graphs of Ni and Li production and price support or refute your predictions.



Graphs to use for part 2B.

Data sources

Graphs in this activity were created by J. Branlund, using data from the following sources:

- Data Presented in the Graphs of Value/Price and Production are from Historical Statistics for Mineral and Mineral Commodities in the United States. USGS Data Series 140. Available at <http://minerals.usgs.gov/ds/2005/140/>.
- Data on Number of Batteries and Metals in Batteries are from D. R. Wilburn (2008), “Material Use in the United States—Selected Case Studies for Cadmium, Cobalt, Lithium, and Nickel in Rechargeable Batteries,” USGS Scientific Investigations Report 2008-5141. Available at <http://pubs.usgs.gov/sir/2008/5141/>.
- Battery Energy Density and Cost is from Isidor Buchmann, *Batteries in a Portable World*. Available at <http://www.buchmann.ca/>.