Example of a Unit Makeover: 10th Grade Chemistry
Batteries and Electromagnetics

Background

The original lesson on batteries has students construct a simple circuit and/use a battery to learn about charges. After connecting two wires to light up a small bulb, students take a multiple-choice quiz and then move onto the next topic.

In this approach, students learn adequately learn about the physical workings of a battery. However, in this lesson, students never think about where their energy comes from, how electricity is generated, and the implications of different energy choices. Moreover, students never examine why such questions about energy have been invisible in our culture for so long. Without this analysis, students will not understand the social factors now driving greater energy awareness; they will also lack a basis for making informed energy decisions in their role as citizens and eventually, workers.

The makeover unit takes a different approach. In addition to going deeply into the chemistry of electromagnetics, the unit engages students in critically assessing the impacts of different types of batteries. As students discover, we cannot have bigger and "better" batteries without bigger waste/disposal issues; this is one of the unit's "Big Ideas."

Along the way, students also gain a historic context on the development of battery technology, and apply their learning to critically assess the viability of electric cars. Can it be done? What will it take? What type of technology is involved? What are the trade-offs in terms of stronger batteries vs. the wastes produced? How could we create a battery that meets energy needs but is sustainable from a product life cycle standpoint? How would we market it?

The makeover unit thus demonstrates how laying a sustainability lens on top of an existing unit results in more rigor, critical thinking, and opportunities for authentic assessment. The use of stations is an excellent way to engage teams of learners in focused investigations of the different issues and technologies.

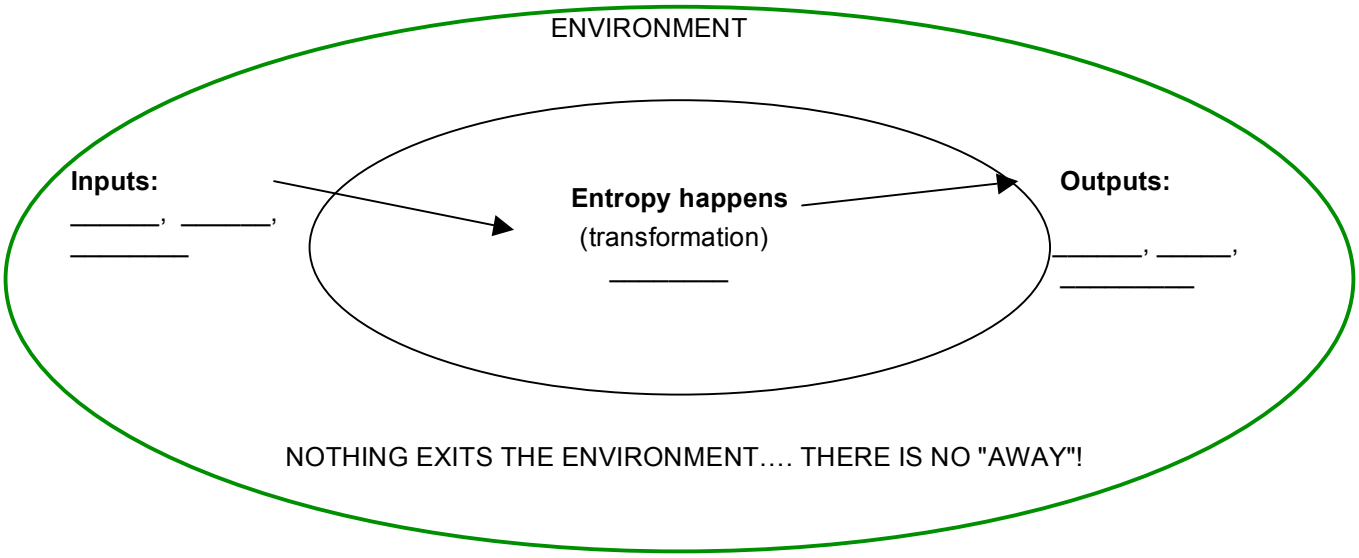
Below are a few ideas (followed by some supporting handouts) on how to further support students as they

- identify the "sustainability" pros/cons of each battery, and
- assess costs/benefits of more powerful batteries and the wastes they produce

Ideas:

1. Analyze the batteries using input-output diagrams.

An input-output diagram (below) is a good way for students to graphically identify the chemicals/metals needed for their batteries, and the waste/pollution produced (inputs and outputs). Moreover, the diagram shows that all outputs stay in the environment ("There is no away." This is a great context to reinforce the First Law of Thermodynamics.")



After they complete the diagram, students should consider what happens to the outputs; this is already in the lesson with questions such as "Identify components to be recycled . . . when the battery is no longer in operation." Additional question could include: Are the outputs toxic and become a burden? Can they be recycled and serve as "food" (inputs) for new products? The input-output diagram is thus a good way to organize students' thinking as they attempt to determine how "sustainable" each choice battery is.

To reinforce "entropy", tie the above to the fact that the batteries become less able to perform work. Thus, heat waste and a loss of energy availability (entropy) is part of the overall picture.

2. Further examine criteria for sustainability

Define sustainability and its criteria; students can use this, along with the input-output diagram information, to assess the advantages/disadvantages of each battery. Included is a table of broad criteria for assessing a product based on each stage of its life cycle (raw materials, production, consumption, etc.). Following that is a blank table where students could take notes. Depending on students' prior knowledge, the teacher would have to present this, and link it to the input-output diagram

Following the blank table is another, optional activity to help students understand criteria for sustainability. The handout presents a spectrum of approaches to "green" practices (ranging from waste reduction to waste elimination), and asks students to consider where everyday products fall along the spectrum. The page could be adapted for this lesson.

What does it mean to be sustainable?

Criteria - organized by life cycle stage

	Traits of products that are *not* sustainable	**Traits of products that are sustainable**
Design	Does not consider the **social** or **environmental costs**	Considers the **social** and **environmental costs**
Raw Materials	non-biodegradable, non-recyclable toxic	biodegradable recyclable non-toxic
Production	Made in ways that - maximize **profits** -provide/obtain lowest costs **Full costs** to **workers** and **the environment** not always considered.	Made in ways that -make a profit - consider **full costs** to **workers** and **the environment** **- provide high quality, durability** Strategies: cooperative and Fair Trade businesses.
Consumption	L**owest price** is important	A **low but fair price** is important. Durability and quality matter.
Disposal	Products go to **landfill,** where they can release pollution into the environment.	Products are **composted** or **recycled,** becoming useful **inputs** for new products. Pollution and energy use are reduced.

Blank table for taking notes

What does it mean to be "sustainable"?

Life cycle stage	Traits of Products that are not sustainable	Traits of Products that are sustainable
Design		
Raw Materials		
Production		
Consumption		
Disposal		

The spectrum below shows another way to assess a product. The little cards below provide examples, and kids can place the items on the spectrum as a way to work with the information.

Reduction approach		Sustainability approach
Reduce waste going to the landfill by using materials more efficiently.	***A. Inputs and outputs*** ⟷	Eliminate the concept of waste. Biodegradable outputs are composted; persistent materials are reused in new products
Reduce or absorb carbon emissions.	***B. Energy use*** ⟷	Eliminate carbon emissions through renewable energy.
Clean up/minimize the impacts of pollution and toxins.	***C. Pollution*** ⟷	Eliminate toxic and polluting substances.

Directions: The cards show different economic practices. Cut out the cards and place them where you think they belong on the spectrum.

On a separate piece of paper, write a few sentences explaining each of your responses. Be ready to present them.

1. This coffee cup contains recycled paper, but is coated with plastic and can't be composted.

2. This coffee cup is coated with corn-based plastic and is compostable.

3. The manufacturers of this computer reduced waste in the production process.

4. The manufacturers of this computer will take it back and upgrade it for resale.

5. This shirt is made of cotton. Wetlands around the field absorb the pesticides and minimize pollution to the rivers.

6. This shirt is made of organic cotton; no pesticides were used.

7. Electricity is generated in a coal-burning plant. Trees are planted to offset the carbon emissions.

8. Electricity is generated through solar collectors.