Lesson Plan: Efficiency

Concepts

1. The efficiency of a system is defined as the ratio of the output energy (or power) to the input energy (or power). These can be measured and calculated.
2. The second law of thermodynamics can describe the energy that cannot be captured and used by humans.
3. The efficiency of a system will decrease as the number of energy conversions increases.
4. A goal of technology is to increase efficiency both directly and indirectly.

Key Questions

1. What is the value in finding a use for energy by-products and where might you find uses for them?
2. If each energy conversion decreases the efficiency, why do we convert the energy several times before we use it?
3. What are the main causes of inefficiency?
4. How can we improve a system’s efficiency?

<table>
<thead>
<tr>
<th>Student Learning Objectives</th>
<th>Standards</th>
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<tbody>
<tr>
<td>The students will be able to explain where energy is lost in conversions and why.</td>
<td>Sci: B3h; Tech: 3,16</td>
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<td>The students will be able to compute the efficiency of an energy conversion given input and output.</td>
<td>Sci: A1h, A2c, B3h Math: IA1, IA3, IA4, IC4, IIA2, IIC1, IVB5, VIB, IXC Tech: 3,16</td>
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<td>The students will be able to identify system by-products and explain how they can be used effectively to increase overall system efficiency</td>
<td>Sci: B3h Tech: 3, 16</td>
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<td>The students will be able to design a simple energy conversion system and test its efficiency.</td>
<td>Sci: A1c, A1d, A1e, A1h, A2c, B3h Math: IA1, IA3, IA4, IC1, IC4, IIA2, IVB5, VIB, IXC Tech: 3, 16</td>
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Students will be able to use data they have collected to measure the efficiency of a system.

**Sci:** A1c, A1d, A1e, A1h, A2c  
**Math:** IA1, IA3, IA4, IC1, IC4, IIA2, IVA1, IVB1, IVB2, IVB5, VIB, IXC  
**Tech:** 3, 16

**Anticipatory Set**

- This Lesson will give the students a background in energy efficiency.
- Students will use the data they collected during their combustion activity to calculate the system efficiency.
- In class they will measure energy outputs and inputs to determine the efficiency of conversions and simple systems. They will learn about byproducts of energy conversions and how to improve upon efficiency.
- The efficiency of a process can sometimes be improved by recovering energy that is lost through inefficient energy conversions. For example, a typical cogeneration facility burns fuel to heat steam which turns electricity-generating turbines. The steam, partially cooled in the first step, is then used to heat homes and businesses. Cogeneration effectively combines two processes of electric and thermal production. Electric generation is roughly 30-40% efficient, adding thermal production in a cogeneration facility can result in overall efficiencies from 80-90%.

**Key Terms**

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<tr>
<th>Efficiency</th>
<th>Input</th>
<th>Output</th>
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<tr>
<td>Generator</td>
<td>Motor</td>
<td>Law of Conservation of Energy</td>
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**Teaching Plan**

**Day 1**

- Review combustion demo done in earlier conversions lesson
  - Does all of heat go into heating the water and/or spinning the turbine? Discuss where energy is lost (at least lost from our ability to do work). Where does this energy go?
  - Reintroduce the laws of thermodynamics:
    - Law of conservation of energy: energy can neither be created nor destroyed (by ordinary means).
  - So how do we “lose” energy? We don’t – we just don’t recover all of it in a usable form following energy conversion processes. Sometimes we want to capture the work (i.e., moving a car), but also generate heat in the process that is
not captured and used (in this case – the engine does not capture and use all of the heat energy released in the internal combustion engine)

- **Introduce Efficiency**
  - Discuss fuel efficiency in automobiles – what does that mean? (more efficient cars use less gas to travel same miles/speed) Why do we care? (may want to even have pictures of different cars, such as hybrid cars, or different systems that are more/less efficient)
  - What does it mean when you are more efficient? You get the job done using less energy!
  - Efficiency is a measure of how well our system works. That is, how much of the energy that is consumed is actually converted into a form that is useful to us.
  - Efficiency = 100% * energy output / energy input
  - Stress terms input and output!!
  - Why is it important to consider the efficiency of our energy systems? (open question)
    - Helps us save natural resources
    - Less effort, energy used if we have a more efficient system.

- **Review efficiency calculation:**
  - Efficiency = (energy out/energy in) x 100%

- **Efficiency of Conversions Activity (3-D Flowcharts)**
  - Split the students into groups of 2-3 students
  - Some of the systems are longer, give the larger ones to groups you know work alittle quicker
  - When the groups have finished have each group report their efficiency and the number of components
  - Have the students make the connection between the larger number of components and lower efficiency.
  - You will have to explain why the solar power system does not fit this trend. There is no way to capture all of the sun’s energy and if we did it would be very dark and cold. ☻ Therefore the solar system’s efficiency is only about 10%.

**Day 2**

- **Efficiency of a System Activity**
  - Ask the students: What happens to a motor shaft when electricity is applied to the terminals? (show that the motor turns, use a battery). Ask about the forms and states of what is happening (chemical to mechanical)
  - Ask: Does anyone has any ideas about what happens to the terminals when the motor shaft is turned? (show that the motor can turn into an electricity “generator” and make it light a lego lamp.) Ask about the forms (mechanical to electromagnetic). Tell the
students that they will be powering their own generators today to lift a weight.

- Have them break into groups of 3-4 students and work at stations with the lego setup. Work through the activity procedures 1-5.
- Explain that you can never have both washers reach the top at the same time because then the system would be 100% efficient. If a system is 100% efficient, all of the energy is being used. Even if the light from the lego lamp was useful to us, there is still heat escaping in the lamp and in the wire. (Maybe talk about recent efforts to achieve 100% efficiency by super-cooling to keep heat from escaping). This might be a good time to look back and compare the efficiencies of sources: solar, wind, gas turbines.
- Go through the rest of the procedure.
- Optional: present the formulas:

\[
\text{power in} = (\text{left washer mass}) \times (\text{left washer distance traveled}) \times \frac{\text{(acceleration of gravity)}}{\text{(time)}}
\]

\[
\text{power out} = (\text{right washer mass}) \times (\text{right washer distance traveled}) \times \frac{\text{(acceleration of gravity)}}{\text{(time)}}
\]

but since the masses are the same, gravity is the same, and time is the same, we only need the distances traveled to find the efficiency since we will be dividing power out / power in. (show this on the board by crossing things out).
- Go through calculations and questions on the activity sheet. The least efficient trial should be trial 3 where loss goes through the wires, 2 bulbs, the motor, and the generator. The most efficient trial should be trial 2 where energy is only lost in the wires, motor and generator.
- Fun Extra: Have the groups connect all of their modules together, and watch the efficiency decrease from motor to motor.

Resources

ACT-Efficiency of Conversions
Teacher’s Guide: Efficiency of a System
ACT- Efficiency of a System