Energy Systems and Solutions Unit

Curricular Unit Title Energy Systems and Solutions

Grade Level 8 (7-8)

Summary

The Energy Systems and Solutions Unit brings students through the exploration of science and engineering concepts as they relate to energy issues in everyday life. Issues surrounding energy production and energy consumption provide a relevant theme for learning basic science, math and engineering concepts, and also provide a convenient platform for introducing current scientific and technological developments into the curriculum. Energy-related issues touch on the lives of each and every student. This project-based curriculum follows an engineering problem solving approach; students simultaneously learn and use scientific and mathematical content and processes as they solve an energy-related problem that is meaningful to them. By challenging them with a problem to solve, students are engaged in scientific and engineering processes, thereby reinforcing subject matter retention and targeting a wide range of learning styles in the classroom. The Energy Systems and Solutions Unit can be broken into three main sections. The first section includes various activities designed to help students understand the problem at hand – namely, the issues surrounding our energy situation - so that they can realize the importance of what they will be studying and the significance of their proposed solutions. An understanding of the problem will form the basis for the student learning that takes place in the second section, which includes basic energy concepts (forms, states, conversions, efficiency, etc.), content that is required by state and federal science educational standards, but they will learn these concepts by participating in a variety of engaging activities that intend to show the relevance of the science material to the real world as well as to the solution of their assigned problem. Finally, in the last section of the unit students apply the concepts they have learned as they complete a culminating project that requires students to consider what action they can take to reduce our dependence of fossil fuels or otherwise provide a positive solution for our current energy crisis.

Engineering Connection

In a broad sense, engineers solve problems, and through their participation in the Energy Systems and Solutions Unit students are modeling what engineers "do." Engineering brings science and math to life, largely through applications toward problem solving. Students apply scientific concepts (forms/states of energy; relationship between energy, work and power; units of energy and power; energy conversions; efficiency; systems and system boundaries, inputs and outputs) and mathematical tools (basic grade-level appropriate math skills such as unit conversions, algebraic equations; graphing) to analyze information and results. Students discuss the pros and cons of their various energy-related decisions, helping them learn to evaluate the impact of their choices in a logical, systematic manner. The Energy Systems and Solutions Unit follows a widely accepted problem solving method that is based on a fundamental process used by practicing engineers. Students start by defining their problem, brainstorming and exploring potential solutions, they test and evaluate their ideas, and ultimately choose the optimum solution which they then implement. The final stage is communication of their results, a skill that is of ultimate importance to practicing engineers and scientists. Through every step of the problem solving process students are applying the math skills and science content that they are learning. Moreover, through the interconnections with societal, political, environmental, and economic themes, the material demonstrates that engineering problem solving is indeed not just a technical or mathematical endeavor, but does relate

significantly to socially relevant issues (renewable vs. nonrenewable resources; fossil fuel resource depletion; global climate change; rising energy costs; environmental and economic impacts related to alternative energy resource development). This "humanitarian side" of engineering, which tends to appeal to a wider range of students, is often lost in more technology-based programs.

Unit Overview

The Unit includes eight basic lessons, each with background information for the instructor as well as suggested teaching schemes. Each lesson contains a number of associated activities, several of which are optional or interchangeable depending on specific classroom situations. The Unit is typically taught over 22 to 25 (40-45 minute) classroom periods. This timeframe can be adjusted depending on the specific goals of the particular class, and there are ample activities provided to extend the unit to a longer timeframe. Estimated teaching days are included in the outline of lessons and activities below. Note that the teaching days are based on including all activities listed in the lesson plan.

The first two lessons complete the initial stages of the problem solving method – students are introduced to the problem and learn to use a systematic problem solving method (students define the problem). The next four lessons provide the student with some of the tools they need to solve their problem – mathematical skills (data collection and manipulation, graphing), system diagram analysis, and fundamental knowledge about energy-related concepts and issues (scientific as well as societal). While learning these tools students are gathering information about potential problem solutions, including some degree of analysis of the different solutions available. Finally, the last two lessons bring the student through the final stages of analyzing and solving the problem, culminating in the production of their final project and presentation (oral and/or written) of their chosen solution.

Subject Area(s)

Physical Science, engineering science

Keywords and **Educational Standards**

- General key words for the overall unit include:
    - Energy
    - Conservation
    - Efficiency
    - Renewable energy
    - Engineering problem solving
- Additional specific key words and educational standards (National and New York State) are included in each of the Lesson Plans.

Related Lessons & Activities

The following table contains an outline of the Lesson Plans and associated Activities in each of the three sections of the Unit. Lesson plan files (underlined) include most of the associated activity sheets. S*upplemental files (italicized),* for example files associated with the Energy

Choices Board Game, the Graphing Activity, and the Home Energy Audit, are included as separate files. Additional *supporting files* in excel or powerpoint formats are also available.

Section / Lesson	Associated activities
Part I – Understanding the Energy Problem	
Introduction-The Energy Problem (6-7 days)	Energy Intelligence Agency
	Energy Carousel
	Energy Choices Board game***f***
	Graphing – Energy facts and statistics ***graphing activity data.xls***
Problem Solving Approaches (1 day)	Egg drop demo
	Example problem solving
Part 2 – Energy Background	
Energy Basics (4 days)	Human Power experiment
	Work, power and energy homework
Forms, States and Conversions (2 days)	Forms and conversions – everyday items
Sources and Systems (7-8 days) ***Energy Sources.ppt*** ***Energy Source Trivia.ppt***	Renew-a-Bead
	Energy Sources Research
	Energy System Diagrams
	Fossil Fuel Graphing Homework
	Energy Jeopardy Game (review)
Efficiency (2 days)	Experimental measurement - Efficiency of a System
Part 3 – Solving the Problem	
Household Conservation and Efficiency (2-3 days)	Using a watt meter
	Home energy audit (***personal energy meter.xls***)
	Light vs. Heat bulb experiment
Final project (4 days)	Final project

Summary Assessment

Homework, activity sheets and quizzes are integrated throughout the curriculum for assessment. The final culminating project provides a summative assessment of the students' learning and ability to apply their new knowledge and conceptual understanding to define an energy problem in their own lives, design and implement a solution to that particular problem.

The set of specific assessment components includes:

Lesson 1:

Energy Choices quiz following Energy Choices Board Game

Graphing Activity can be assessed by evaluating oral presentation or from printed graphs and discussion question responses

Lesson 2:

Problem Solving Process group activity (worksheet turned in or discussed)

Lesson 3:

Vocabulary sheets (optional, check if completed)
Homework assignment: Big Bad Wolf (work/power)
Human Power Activity data sheet and discussion questions
Energy Basics Quiz

Lesson 4:

Energy Forms and Conversions Activity discussion questions

Lesson 5:

Energy Sources and Conversions Worksheet
Renew-a-bean Activity data sheet and discussion questions
Homework assignment: Fossil Fuel Use (graphing, questions)
Energy Resources Research Activity questions, oral presentation and written answers to discussion questions
Energy Systems Diagrams Activity discussion questions
Energy Sources, Systems and Conversions Quiz

Lesson 6:

Efficiency of a System Activity data sheet and discussion questions

Lesson 7:

Watt Meter Activity data sheet, discussion questions
Homework: Home Energy Audit
Light vs. Heat Bulbs Activity data sheet, discussion questions, Life Cycle Analysis
Homework: Home Light Bulb Use

Lesson 8:

Homework: Energy Project Ideas
Homework: Energy Decisions
Final Culminating Project

Energy Systems – Vocabulary and Definitions

Biomass energy	Energy released from plant or animal material (wood, corn, animal fat etc.) through combustion or other chemical process
Block Process Flow Diagram	A physical representation of inputs and outputs of a process, used by engineers.
Chemical energy	Energy stored within chemical bonds.
Combustion	The process of burning organic chemicals to release heat and light.
Compact Fluorescent Light Bulb (CFL)	A new light bulb that converts electricity into light through the excitation of

Conservation	Careful use of resources with the goal of reducing environmental damage or resource depletion.
Efficiency	Ability of a process or machine to convert energy input to energy output, efficiency is always less than 100% in real processes. Efficiency of a system can be quantified as the ratio of the useful output energy (or power) to the input energy (or power)
Electrical energy	Energy made available by the flow of electric charge through a conductor.
Electromagnetic energy	A form of energy that is reflected or emitted from objects in the form of electrical and magnetic waves that can travel through space Examples include gamma rays, x rays, ultraviolet radiation, visible light, infrared radiation, microwaves and radio waves
Energy	the ability to do work = power x time
Energy Audit	A study of energy use and losses in a home, business or other system
Energy Conversion	Transformation of one form of energy into another, usually to convert the energy into a more useful form
Energy System	An energy system is made up of a sequence of conversions with inputs and outputs that transform an energy resource into a form usable for human work or heating
Entropy	Entropy is a thermodynamic measure of how dispersed and unusable energy becomes over time as it is converted between forms.
First Law of Thermodynamics	Energy can neither be created nor destroyed.
Force	A force is a push, pull, or twist =mass x acceleration (acceleration often associated with gravity (g), as in potential energy)
Form of energy	Forms of energy include heat, light, electrical, mechanical, nuclear, sound and chemical
Fossil Fuel	A non-renewable energy resource that began to form millions of years ago from the remains of once living plants and animals. Its current forms include petroleum, coal and natural gas.
Generator	A machine to convert mechanical energy into electricity
Geothermal Energy	Heat energy from the earth
Heat	A form of energy related to its temperature
Input	Matter or energy going into a process
Hydropower	Transformation of the energy stored in a depth of water into electricity
Incandescent bulb	Traditional light bulb that converts electricity to light by heating a thin wire until it glows
Kinetic energy	Energy of motion, influenced by an objects mass and speed
LED	A Light Emitting Diode (LED) is a solid-state semiconductor device that converts electrical energy directly into light. The process of an electron moving in the semi-conductor releases energy and produces photons with visible wavelengths.

Life cycle cost analysis	Analysis of the total capital and operating cost of a product
Mechanical energy	A form of energy related to the movement of an object
Motor	A machine that converts electricity into mechanical energy, generally for a rotational device
Non renewable energy	Resources, such as fossil fuels that cannot be replaced by natural processes at the same rate it is consumed
Nuclear energy	Energy produced by splitting the nuclei of certain elements
Output	Matter or energy coming out of a process
Peak oil	The point at which the rate that a non-renewable resource (oil) can be produced declines due to the limitations of extraction processes and the availability of the resource.
Photovoltaic	A chemical process that releases electrons from a semi-conductor material in the presence of sunlight to generate electricity.
Potential energy	Energy that is stored and that comes from an object's position or condition.
Power	The rate at which work is done = work / time (or =energy/time)
Renewable energy	Resources, such as wind and water, that can be recycled or replaced at a rate faster than they are consumed.
Second Law of Thermodynamics	The Second Law of Thermodynamics, which is also known as the Law of Increased Entropy, helps to explain energy (or mass) "losses." It explains why the ***quality*** of energy deteriorates gradually over time as it gets dispersed in unusable forms. The usable energy is irretrievably lost from productive activities.
Solar Energy	Energy from the sun; often captured directly as heat or as electricity through a photovoltaic process.
State of energy	States of energy include kinetic and potential
System Component	One process in a system comprised of many processes or components
Thermodynamics	is the study of energy – derived from the Greek roots "heat" and "power"
Uranium	An element that releases heat as it undergoes radioactive decay
Wind energy	Energy transferred with the motion of air in the lower atmosphere that arises from differential heating of the earth. The energy in the wind can be extracted as mechanical energy to do work such as grind grains (a wind mill) or generate electricity (wind turbine)
Work	Work is a force acting over a distance to move an object= force x distance

Units Pertinent to Energy Systems

Btu	The amount of energy needed to raise 1 lb of water 1 degree Fahrenheit (1 Btu ~ heat energy from one wooden match). 1 Btu = 1055 Joules

Horsepower	A measure of power, used for both mechanical and electric power (hp), 1 hp = 746 watts
Joule	the SI unit for energy and work. (J) (J = W·s = N·m)
Kilogram	the SI unit for mass (kg) (1 kg = 1000 g)
Kilowatt	Typical unit for electrical power. 1 kW = 1000 watts
Kilowatt hour	Typical unit for electrical energy (kWh)
Meter	the SI (Standard International) unit for distance (m)
Newton	The SI unit for force (N) (N =kg/m/s^2)
Watt	Basic unit for electric power (W) (W=J/s)

References

Definitions and concepts based on New York State standards and the textbook:

Biggs, A., Burns, J., Daniel, L.H., Ezralson, C., Feather, R.M., Horton, P.M., McCarthy, T.K., Ortleb, E., Snyder, S.L., Werwa, E. Science Voyages: Exploring Life, Earth and Physical Science, Level Red., Glencoe/McGraw Hill: New York, 2000.

Intermediate Level Science Core Curriculum, Grades 5-8, New York State Education, Department, accessed December 31, 2008. http://www.emsc.nysed.gov/ciai/mst/pub/intersci.pdf

URL

All unit and lesson plans defined above are included at http://www.clarkson.edu/highschool/k12/project/energysystems.html

All of the Energy Choices Game files are available at:

http://www.clarkson.edu/highschool/k12/project/energychoicesgame.html

This URL has been included in the Engineering Pathways web site (http://www.engineeringpathway.com/ep/index.jhtml) and can be found with a search on “energy choices.”

Owner

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Contributors

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