Energy in Today's Global Society

Grades: 9-12

Topic: Energy Basics

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Owner: ACTS

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TITLE:
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GRADE LEVEL/SUBJECT:
9-12, Physics, Chemistry, Earth Science, or Environmental Science

Article I. RELEVANT CURRICULUM STANDARS:

Process/Skills:

National Science Education Standards

Standard A: *Science as Inquiry*
Standard E: *Science and Technology*

Benchmarks for Science Literacy

Standard 1B: *Scientific Inquiry*
Standard 1C: *The Scientific Enterprise*
Standard 3A: *Technology and Science*
Standard 3B: *Design and Systems*
Standard 12C: *Manipulation and Observation*
Standard 12D: *Communication Skills*
Standard 12 E: *Critical Response Skills*

Connecticut State Dept. of Education Core Science Curriculum Framework (Oct. 2004)

Content Standard SCIENTIFIC INQUIRY: *Scientific inquiry is a thoughtful and coordinated attempt to search out, describe, explain and predict natural phenomena. Scientific inquiry progresses through a continuous process of questioning, data collection, analysis and interpretation. Scientific inquiry requires the sharing of findings and ideas for critical review by colleagues and other scientists.*

Content Standard SCIENTIFIC LITERACY: *Scientific literacy includes the ability to read, write, discuss and present coherent ideas about science. Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media.*

Content Standard SCIENTIFIC NUMERACY: *Scientific numeracy includes the ability to use mathematical operations and procedures to calculate, analyze and present scientific data and ideas.*

Expected Performances:

D INQ.1 *Identify questions that can be answered through scientific investigation.*

D INQ.2 *Read, interpret and examine the credibility and validity of scientific claims in different sources of information.*
D INQ.3 *Formulate a testable hypothesis and demonstrate logical connections between the scientific concepts guiding the hypothesis and the design of the experiment.*
D INQ.4 *Design and conduct appropriate types of scientific investigations to answer different questions.*
D INQ.5 *Identify independent and dependent variables, including those that are kept constant and those used as controls.*
D INQ.6 *Use appropriate tools and techniques to make observations and gather data.*
D INQ.7 *Assess the reliability of the data that was generated in the investigation.*
D INQ.8 *Use mathematical operations to analyze and interpret data, and present relationships between variables in appropriate forms.*
D INQ.9 *Articulate conclusions and explanations based on research data, and assess results based on the design of the investigation.*
D INQ.10 *Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.*

Content:
National Science Education Standards
Standard B: *Conservation of Energy and the Increase in Disorder*
Standard F: *Science in Personal and Social Perspectives; Natural Resources*

Benchmarks for Science Literacy
Standard 3C: *Issues in Technology*
Standard 4E: *Energy Transformations*
Standard 8C: *Energy Sources and Use*

Connecticut State Dept. of Education Core Science Curriculum Framework (Oct. 2004)
Content Standard 9.3: *Various sources of energy are used by humans and all have advantages and disadvantages*

- *During the burning of fossil fuels, stored chemical energy is converted to electrical energy through heat transfer processes.*
- *In nuclear fission, matter is transformed directly into energy in a process that is several million times as energetic as chemical burning.*
- *Alternative energy sources are being explored and used to address the disadvantages of using fossil and nuclear fuels.*

TEACHER'S OVERVIEW:

Energy is an abstract concept that is very familiar to students from personal experiences with household appliances, transportation, and their own bodies. However, the nature of energy, energy transformations, and energy conservation are poorly understood, even by most adults. The geopolitical and environmental issues associated with energy and its consumption in today's global society are important for every citizen to appreciate in order to make informed decisions about the future. Without a deep understanding that energy is finite and that energy transformations are what give modern society its high standard of living, students today will not be prepared to make the tough personal and political decisions that await us as fossil fuel resources dwindle.

To this end, this unit strives to incorporate the science behind current and future energy technologies within an inquiry and application based framework. It builds on the mastery of CT Standards 9.1: Energy can not be created or destroyed; however, energy can be converted from one form to another, and 9.2: The electrical force is a universal force that exists between any two charged objects. Through the use of innovative resource cards that students create themselves, students will learn that all fossil fuel-based energy provides many benefits for those that can take advantage of the power, but comes at a high environmental cost. One of these is the enhancement of global climate change by increasing anthropogenic carbon dioxide and methane emissions. Students will weigh these costs and benefits against those of other energy sources. Electricity alternatives include nuclear, hydro, biomass, solar, geothermal, hydrogen fuel cells, and wind. Heating alternatives include geothermal, biomass and solar. Transportation alternatives include biofuels such as ethanol and biodiesel, hydrogen fuel cells, and electric/hybrid engines. It is important that the teacher remind students as the unit progresses that all societies across the globe need access to reliable fuel for electricity, transportation, and business/domestic uses in order to develop and maintain a high standard of living.

All of these energy sources will be compared and analyzed for the final project. Students will research an energy source and present it to their classmates. They will then use the information, plus all the content from class lectures and activities, to design a "Planned Community". This community must have power supplied to it 24/7. It also must be an affordable and eco-friendly place to live, so students must account for the costs and benefits of energy production and consumption. In the end, students will have a deep understanding of not only the conceptual science of energy, but also of the technical and societal issues as well.

LEARNING OBJECTIVES:

By the end of this unit, students will know and understand that:

D 7. Explain how is heat used to generate electricity.

D 8. Describe the availability, current uses and environmental issues related to the use of fossil and nuclear fuels to produce electricity.

D 9. Describe the availability, current uses and environmental issues related to the use of hydrogen fuel cells, wind and solar energy to produce electricity.

(From the CT Core Science Framework, Std. 9.3 Expected Performances)

TIME ALLOTTED: 4 to 5 weeks, 6 x 45 minutes periods per week.

VOCABULARY:

Climate Change	Grid
Combustion	Load
Emission	Passive and Active Solar Energy
Fission	Photovoltaic Cell
Fossil Fuel	Renewable Energy
Fuel Cell	Standard of Living
Geothermal Energy	Sustainable Energy

RESOURCES/MATERIALS: (all non-referenced materials are attached)

Handouts and References:

1. PreQuiz : http://www.eia.doe.gov/kids/energy_fungames/quiz/index.html
   This can be adapted to level and answers removed for initial knowledge assessment. CT Core Standards 9.1 and 9.2 can also be added.
2. Pie charts and arrow diagrams for current year's US and global energy usage. Teacher or student generated depending on time allotted. http://www.eia.doe.gov/kids/energyfacts/uses/consumption.html
3. Pie charts for current year's US and global energy generation. Teacher or student generated depending on time allotted. http://www.eia.doe.gov/kids/energyfacts/uses/consumption.html
4. Overhead of centralized vs. distributed power community diagram
5. Overhead of the electrical grid system
6. Overhead of 5x7 index card power plant diagram. It is important for students to draw their own diagrams! One fuel, transportation, and heat/cooking source can be chosen as a demonstration, usually oil or coal.
7. *Modern Marvels: Power Plants* DVD from The History Channel Store, $24.95
8. Heat Transmission Laboratory Description
9. Nuclear Decay Laboratory: there are many versions online. This one is based on M&M's: http://www.science-house.org/learn/CountertopChem/exp32.html

9\. Energy Project description and rubric

10\. Biodiesel Laboratory description and rubric
Can be adapted to class from http://makezine.com/03/biodiesel/

11\. State of CT Curriculum-Embedded Performance Task, Strand I: Energy Transformations: Solar Cooker. Teacher and student materials can be found at http://www.state.ct.us/sde/DTL/curriculum/currsciembed.htm

12\. *Nova scienceNow: Fuel Cells* 14 minute Quicktime video from July 2005
Can be downloaded from http://www.pbs.org/wgbh/nova/sciencenow/3210/01.html.

13 State of CT Curriculum-Embedded Performance Task, Strand I: Energy Transformations: Uses of Energy in Connecticut STS Activity. Teacher and student materials can be found at http://www.state.ct.us/sde/DTL/curriculum/currsciembed.htm

Class/Laboratory Materials:

Energy Cards:

Index cards, 3x5 and 5x8
Rulers
Colored Pencils

Heat Transmission Lab:

100 W clip-on lamps
Glass blocks with holes in them, or another sealable large (2L) glass container
Cardboard boxes that fit the glass containers on one side
Thermometers
Various gasses (air, CO_2 (from dry ice or vinegar/baking soda reaction), or car exhaust) and water or steam

Nuclear Decay Lab, Biodiesel Lab, Solar Cooker Lab

See web pages cited above

PREREQUISITE KNOWLEDGE:

CT Standard 9.1: Energy can not be created or destroyed; however, energy can be converted from one form to another.
CT Standard 9.2: The electrical force is a universal force that exists between any two charged objects.

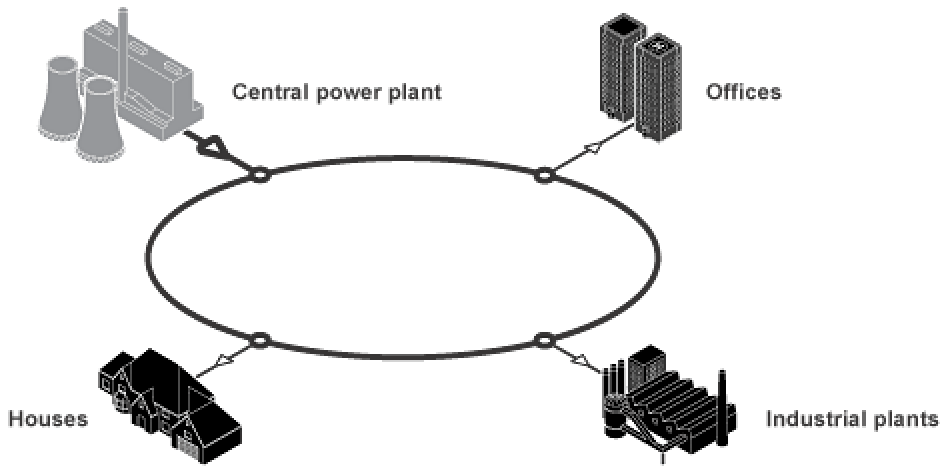
MAIN ACTIVITIES: (* = labs)

- *Assessment:* Pretest
- *Discussion/Lecture:* Identification of where energy is used in society (electricity, transportation, heat/cooking) using current pie charts and diagrams from www.eia.gov.
- *Discussion*: Central vs. distributed energy (power plant vs. local generator).
- *Activity/Lecture:* Basic Power Plant preparation and grid/load discussion.
- *Video*: *Modern Marvels Power Plants* Part I: Power plants and how they work, grid and load system.
- *Activity/Lecture:* Coal power plant heat source cards
- *Activity/Lecture:* Coal heat/cooking cards
- *Activity/Lecture:* Cost/benefit analysis of coal discussion and fill in of cards
- *Assessment:* Assign Energy Project
- **Laboratory:* Heat Transmission Lab. Add results to fossil fuel/biomass cards.
- *Assessment:* Begin Energy Project Presentations, to be lead by individual teams, in the following order:
    - Nuclear fuel heat source card and cost/benefit analysis
    - Biomass heat source, transportation, and heat/cooking cards and cost/benefit analysis
        - **Laboratory:* Make biodiesel and test, if possible
    - Solar heat source, photovoltaic, and heat/cooking cards (Where does PV card go??)

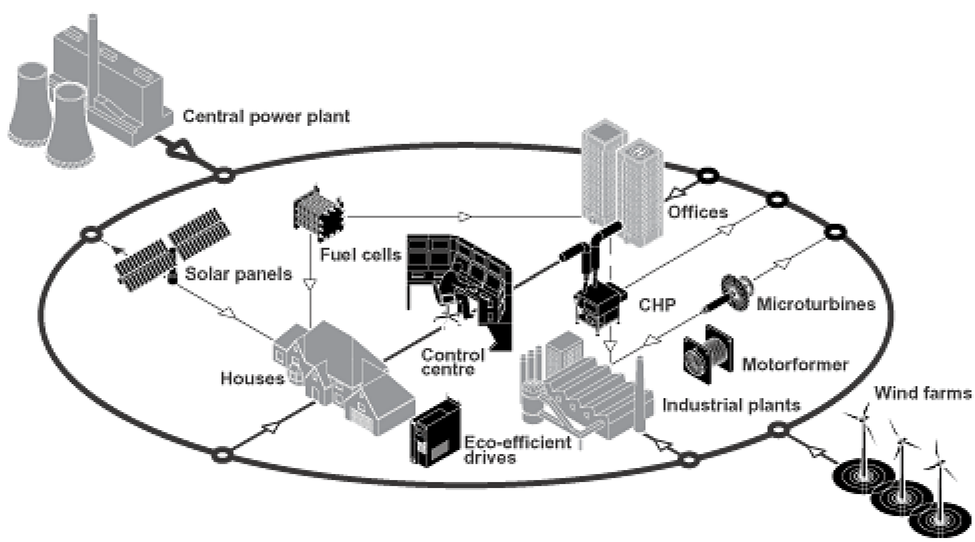
        - **Laboratory:* State of CT Curriculum-Embedded Performance Task, Strand I: Energy Transformations: Solar Cooker
    - Cost/benefit analysis of solar
    - Geothermal heat source, heat/cooking cards and cost/benefit analysis
    - Hydro and Wind electricity cards (fit in over turbine and heat exchanger) and cost/benefit analysis
    - Fuel cell transportation and heat/cooking cards
        - *Video:* Fuel cell excerpt from Nova scienceNow
    - Cost/benefit analysis of fuel cells/hydrogen
- *Assessment*: State of CT Curriculum-Embedded Performance Task, Strand I: Energy Transformations: Uses of Energy in Connecticut STS Activity
- *Video*: *Modern Marvels Power Plants* Part II: Alternative Energies and cost/benefit analysis (review).
- *Assessment*: Design an energy plan for a new planned community in California. Present to class for review.
- *Assessment*: Posttest and other objective evaluations as deemed necessary.

EVALUATION:
Pretest/posttest comparison
Peer review of energy cards and presentations
Lab reports and analysis
Final project – Energy Plans with peer review

Overhead of Central vs. Distributed Electricity Generation Systems

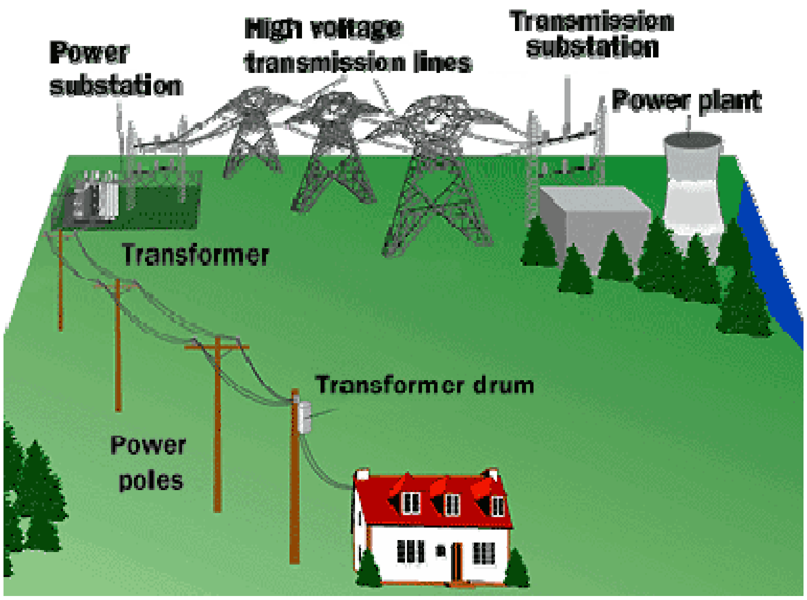


http://www.abb.com/cawp/seitp255/205647afe5e0412dc1256c6a00487104.aspx

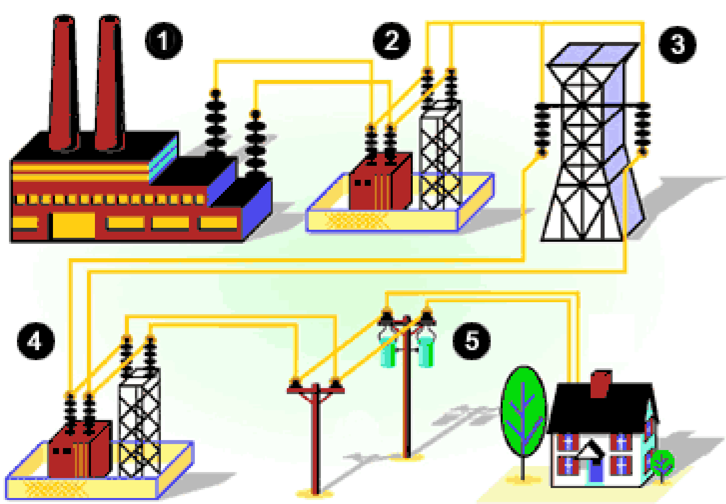


http://www.abb.com/cawp/seitp255/c1d7a7d40f1b53efc1256c6a00487105.aspx

Overhead of Electric Grid System

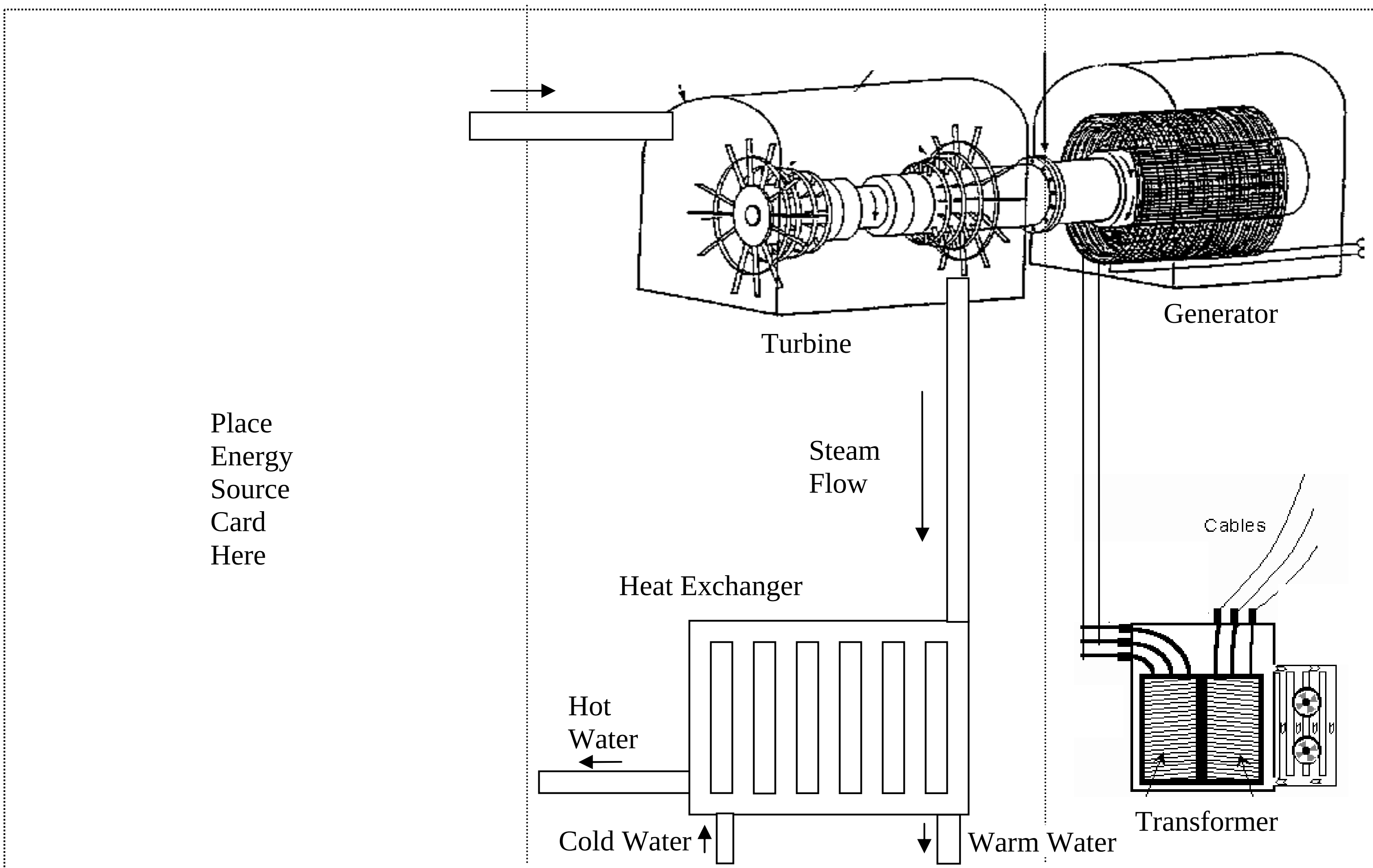


http://science.howstuffworks.com/power.htm



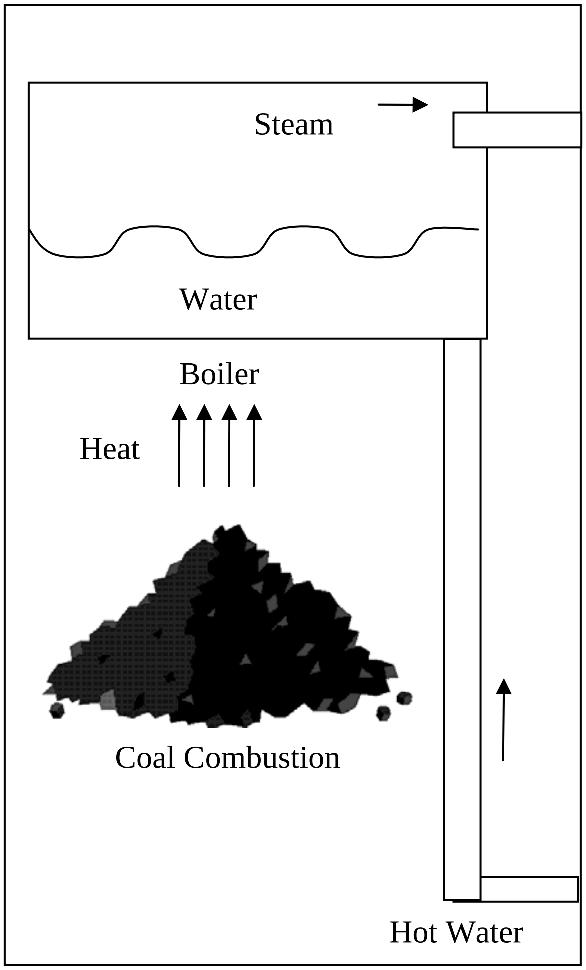
http://potomac.mirant.com/powergrid/index.html

Overhead of Power Plant 5x8 Schematic



Overhead of Energy Card Ideas: Coal

FRONT



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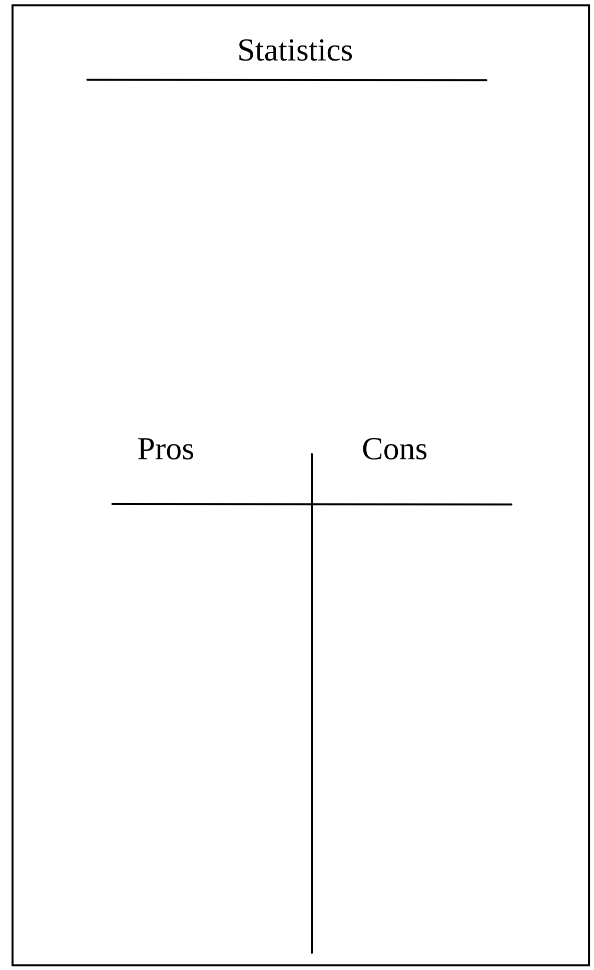
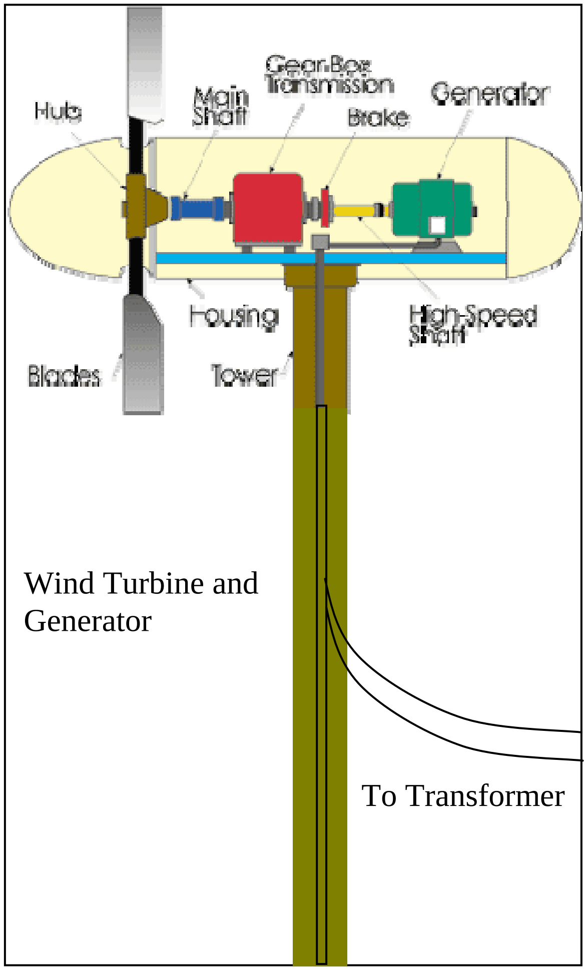


Overhead of Energy Card Ideas: Wind: PLACE OVER TURBINE AND HEAT EXCHANGER

FRONT



BACK

Statistics

Pros	Cons

Heat Transmission Lab Description

Purpose: to determine the effect of different gasses on the transmission of infrared radiation.

Introduction: There is much talk today about "global warming" and the effect of anthropogenic atmospheric gasses on the natural greenhouse effect. In this investigation, students will determine the effect of different gasses or liquids on the transmission of heat (infrared radiation) across a glass container. A review of the electromagnetic spectrum and the energy balance of the Earth system is recommended before beginning. This activity was adapted from the AP Biology Transpiration lab (#9). For this application, the light bulb acts as the radiation source: the surface of the Earth, as shown in Figures 1 and 2. The glass container, filled with air, CO_2, water, or whatever substance the students want to investigate, is the atmosphere. A square container, such as a glass block, is the ideal vessel, but these are hard to find. The box with the thermometer is outer space.

Figure 1.
AP Biology Transpiration Laboratory

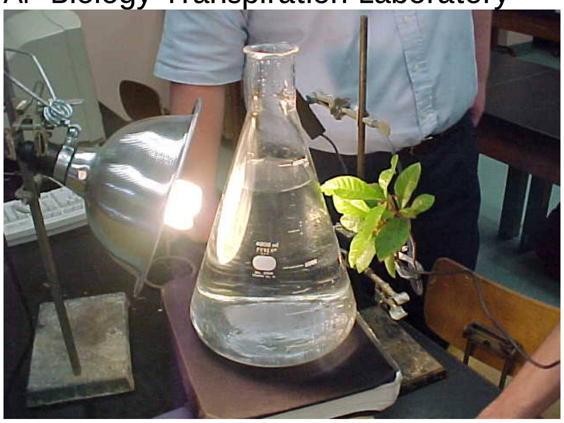
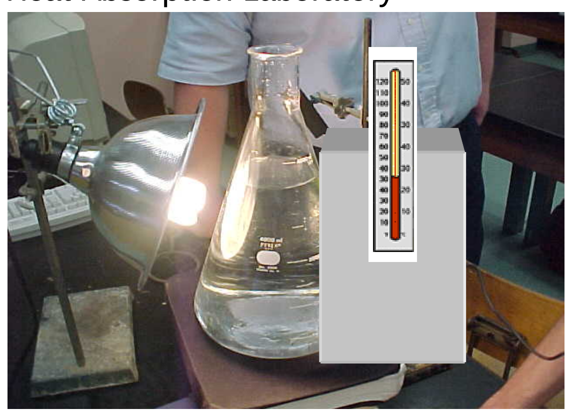


Figure 2.
Heat Absorption Laboratory



Procedure:

1. Set up a "model Earth" as shown in Figure 2. A shoebox works well. If the container for the gas is not square, as is this 2L Erlenmeyer flask, use construction paper and duct tape to seal the container to the box. Choice of light bulb is important. A regular 60 or 100 W incandescent bulb will produce a sufficient amount of infrared light. Fluorescent bulbs will NOT work as well, and red "heat bulbs" will work the best, but can be expensive.
2. Fill the container with a gas. Use air as a control. You can assign different groups different gasses, including CO_2 from dry ice or an acid/baking soda reaction, methane (natural gas) from the lab gas jet (BE CAREFUL!! Methane is FLAMMIBLE! Do this one in a fume hood), car exhaust, and steam. Liquids can also be used. Be creative.

3. Turn on the light, and begin to take temperature measurements every 1 to 5 minutes for at least 30 minutes. Depending on the gas/liquid involved, it may take up to an hour to get noticeable results.

Results: Students should see a noticeable difference in the slope of the heating curves between the different substances in the glass container. Data should be graphed and presented to the class, and then pooled into one graph for comparison. For upper level students, a t-test can be performed on the final temperatures (if enough replicates are run) to determine the significance of the effects.

Discussion and Conclusions: Students should make the connection between the type of substance in the container and the amount of heat transferred into the box. The greater difficulty will be in correctly applying the results to the actual "greenhouse effect" phenomenon. The experimental design is counter-intuitive: most students believe the light bulb is the sun, not the Earth. While using the bulb as sun is a valid experiment, it is not the problem that is investigated here. The focus of this lab is the trapping of heat on the Earth by atmospheric gasses, NOT the transmission of light energy from the sun. For lower level students, the use of a "heat bulb" that is red in color may help to avoid the confusion.

Extensions:

1. Use different light bulbs after their output spectrum has been determined.
2. Vary the distance between the light source and the glass container.

Energy Source Project

E presentation – Due ________________
Town Manager Report – Due __________

You are town managers for a new planned community in California. Due to recent energy supply problems and the environmental philosophy of the target demographic, you need to develop a plan for providing energy for the region at a low cost and minimal environmental impact. It also needs to be usable into the future – at least 50 years. These communities cut across a wide range of ecosystems (including windy ocean coastline and arid inland areas), so there are many options. You have an agreement with the State Energy Commission that will provide you with funds for building a power plant (or plants) for your region. All you have to do is **develop a plan and support your ideas with current data and theories, with references.**

Fortunately, your day job is running a company that installs power systems. Your task is to convince your colleagues in Town Hall that your method of power production will help solve their energy problems. You will make energy source 3x5 cards for your fuel, including electricity, transportation, and heat/cooking cards. You will present your cards and your arguments to the Town Managers before they make their decisions. You will also be competing with other companies that supply different forms of power generation, so you need to back up your claims with

a description of your power source and how it works,
current data on usage and supply in the US,
cost and reliability compared to other methods of power generation.
and examples of other regions that are using this type of system, with references.

And, be concise and convincing. Remember, you are competing against other companies! Point out your strengths and others' weaknesses! Visual aids (as in PowerPoint) would be helpful!

The following are the types of power supplies that are available:

- Coal (class demo)
- Oil/Petroleum
- Natural Gas
- Solar Options
  - Thermal collectors
  - Photovoltaics
  - Active and passive building designs
- Wind
- Biomass
- Nuclear
- Geothermal
- Hydrogen Fuel Cells

> Remember, there can be different systems providing energy for different purposes. You are designing a planned community, so you can install any type of heat/cool/hot water system in the houses and business, and draw your electrical energy from any source.

The following web sites may be useful:
www.enviroliteracy.org , energy.gov, www.eia.doe.gov/ , www.nrel.gov/

Rubric for Energy Presentations

Names: Topic: Time:

Accurate and understandable description of power source and how it works

5 incomplete and incoherent, cards missing or incomplete
10 about 60% of info, confusing, cards present but large gaps of information
12 mostly there but a little confusing, cards complete but disorganized, hard to read
15 complete and very understandable, all cards neat and very readable

Data on usage and cost in US

3 some data, but not current or related to planned community
5 good data that relates to the planned community

Persuasive arguments that compare your source to others

3 You've convinced me that I DON'T want your power!
5 I'm on the fence . . . there are major issues that you didn't mention.
8 I'm interested, but I've got some issues to resolve that you didn't fully address.
10 Wow, I want one of those!

Presentation is organized and well practiced

0 awful; tripping over one another
3 giggles and pauses in presentation
5 flawless and very smooth delivery

notes and references

0 none
3 limited and disorganized
5 excellent and well organized.

My Notes:

Rubric for Energy Plans

Plan is logical, accounts for electric power 24/7, addresses needs of homes, businesses and general town-wide infrastructure and activities, and is supported with sound reasoning.

5 incomplete and incoherent; why did you bother?
10 about 60% of info; makes some sense but not really feasible
12 mostly there but a little confusing; some needs not addressed
15 complete and very understandable; nice work!

Generalized discussion and accounting of monetary cost.

3 some data, but not current or really related to planned community
5 good data that relates to the planned community

Generalized discussion and accounting of environmental cost and impact.

5 You've convinced me that you haven't been paying any attention to anything.
8 Not bad, but you've missed a few key ideas.
10 Wow, you really know what you're talking about!

Grammar, spelling, and structure of persuasive essay would impress your favorite English teacher.

0 awful; a 4th grader could do better.
3 some mistakes, choppy flow, not very persuasive, too informal
5 professional quality

References: every piece of information that is not your own original idea is noted and referenced. For others' presentations, just cite "So and so's class presentation on blah."

0 none; you are delusional and think you did all this work in a vacuum.
3 limited and disorganized, or unintentional plagiarism suspected.
5 excellent, well organized, and complete.

My notes: