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# How Green Is Our School? Energy Conservation Challenge 2012

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## Preface

Energy conservation is touted by some as the new "alternative energy resource," and this is a resource which requires very little technical or industry knowledge to extract. It only needs an informed perspective on the relevance and necessity of personal practices and habits of mind that contribute to conservation of our energy sources. Central to the unit are the types of conservation actions and proposals that will be attainable to and developed by students. Student investigations of energy consumption through both Personal Energy Inventories as well as a School-Wide Energy Audit and the development of energy consumption proposals are the foci of the unit and will be discussed in those sections below.

While the fundamental nexus of this narrative is energy conservation, many routes must be taken to approach this topic with some scientific literacy and understanding of the social and political facets involved. The following introductory passages are highly subjective and intentionally present a one-sided argument. These thoughts are included to give an emotional or ethical context to the topic of energy conservation and its necessity as part of a global sustainable energy future. It is also intended to be a strategy for encouraging student interest and personal involvement in the unit content.

Evoking student interest in purely fundamental science concepts is often difficult, as these may lack clear relevance to their experience and world view. It is frequently effective to frame the content within applicable societal issues, especially when taken from the public opinion standpoint. The introduction of this unit is decidedly from the antagonist, pseudo-sensationalist perspective. One must beware that the use of exaggerated details and claims does not undermine the validity and scientific background of the issues relating to energy conservation; nevertheless, this tactic may be a developmentally appropriate strategy for engaging my adolescent audience. This aim is also sought by the use of general inspirational quotes included throughout this narrative, which are not only very broadly applicable but also directed toward the unit content. These quotes are not included in this narrative in order to reinforce the content; rather, they are intentionally placed within the narrative to supplement the content and may be used during instruction to generate student interest and stimulate participation in classroom discussions.

## Introduction

Issues of energy and the environment are not new to the scope of problems facing concerned humans in the twentieth and now twenty-first centuries. Now, however, there is a desensitization of those of us in the general public as the issue has become passé, greatly confined to sound-bites, headlines, rhetoric, campaign platforms, and bumper stickers. There is a preponderance of doom, gloom, assigning blame, and "passing the buck" in most discussions on the state of the environment, particularly in dealing with those issues with which modern human societies must contend as a result of carelessness and a lack of foresight on the part of past human actions.

Remediation is slow and expensive, if possible at all. Wherever we turn, we are exposed to a multitude of unseen toxins with unknown implications for our health. Species are destined for extinction, as habitat is consumed by human development at the prerogative property values. The government is either paralyzed or crippled by special interest groups and share-holders in the private sector. The public feels disenfranchised, deceived, manipulated, misinformed, uninformed, unaware, powerless or down-right apathetic. There is a limited and unequal distribution of resources to meet the demands of a burgeoning world population, yet many of us continue to buy the biggest and fastest petroleum fueled automobiles and just can't wait for the next generation of our mobile device to be introduced to the market so we can throw our antiquated two-year-old model into a landfill. And, in a world of unprecedented technological advances and access to information and communications, the citizens of the world and super-power nations are further from solutions to resource depletion than we were four decades ago, and we still can't seem to agree on a unified path to positive global change on the environmental front.

But, that's not the full story. The success stories are out there; the world's innovators and environmentally conscious investors are already making considerable progress. Environmental awareness has expanded beyond the realm of a concerned few and well into the general public. Where issues of public health are concerned, there have been notable changes in regulation and the production of persistent toxic chemicals, including cases in point of DDT, pesticides, heavy metals, and a recognition of the chemical complexity of the built environment. The history of nuclear weapons atmospheric testing also saw success in bringing that practice to a halt. [1] States and municipalities have set goals of energy conservation and renewable resource implementation. The future holds great promise for innovation and progress toward solving complex environmental problems, and it is a goal of this unit to inspire students to be a part of those solutions.

However, much of that progress is still "behind the scenes" and accessible only to those with the intellectual and industry experience as well as the capital and social mobility to make headway in the quagmire of human-induced environmental issues. I, for one, need to hear a story of hope for the pedestrian consumer; I need to believe that we can get it right. I need to have faith that human ingenuity will overcome more than a century of myopic and ill-fated technological, regulative, policy, and manufacturing decisions. Although I would never consider myself a pessimist, I need to indulge, on occasion, in a little good ole shameless optimism. And, so do the young people of the new generation, our children, our students. They have heard that we humans are to blame for the myriad environmental problems facing the nations of the world today; that they must strive to remedy the folly of those who paved so much before them, and that the pursuit of the American Dream is responsible for the nightmares we all now face. However, they also have it within them to seek answers and solutions and must also hear that the wealth of human resourcefulness and inspiration is far from bankrupt; we do not need to be victims of our own circumstance; we can create our own destiny and follow our own path to global environmental redemption. It is important to realize the power of the individual in taking actions to mitigate the host of environmental problems that stem from a disproportionate reliance on petroleum energy sources.

You may say I'm a dreamer, but I'm not the only one. [2]

## Demographics and Description of Course

This unit is designed for my ninth grade Earth Science students. These high school freshmen are attending Jefferson High School in Daly City, California, and they come to us from a handful of middle schools both within the district as well as inter-district transfers from San Francisco and East Bay school districts. Our student population is ethnically diverse; however, the majority of students reflect the local population demographics with 44% Hispanic or Latino ethnicities and 32% Filipino as reported in the 2010-2011 School Accountability Report Card (SARC) [3] ; according to the same report, the remaining ethnic constituents of Jefferson High School are 7% two or more races, 6% Black/African American, 6% Asian, 3% Pacific Islander, and 3% White (not Hispanic). 60% are classified as Economically Disadvantaged, approximately 70% come from families where English is not the primary language, whereas 46% of students are designated as English Language Learners, 6% are identified as Students with Disabilities. The percentage of our students on the subsidized meal plan is historically high, with 65% qualifying in 2011-2012. [4]

Earth Science at Jefferson High School is intended as an introductory course to upper level college prep science courses. It is designed to ready students for advancement to these science courses by providing both foundational knowledge and basic skills through a diverse curriculum across four main branches of study: Geology, Meteorology, Oceanography, and Astronomy. This unit in Earth Science is designed as a precursor to both the Geology and Meteorology units, and as such will be covered in the beginning of the yearlong curriculum. I will deliver information that will recur throughout the course curriculum, namely in the aforementioned branches of Earth Science. However, the content of the unit is applicable to other course curricula within the physical and environmental sciences, and could easily be incorporated therein. The relevance of the unit to course curriculum will be further discussed in the Rationale and Background sections below.

## Learning Objectives

I try to infuse my Earth Science instruction with environmental issues in alignment with the standards-based curriculum. The general theme of "environmental stewardship" is introductory to the course and appears throughout many units I teach in Earth Science. I would like this unit to impart a sense of environmental responsibility, conscious living, and critical consumerism to my students. In addition to the underlying "environmental morality" of the unit, it is intended that students gain a basic understanding of fundamental science concepts and skills that will be built upon in subsequent units of instruction in Earth Science as well as the Biology and Physical Science requirements they must fulfill as they matriculate through their sophomore, junior, and senior years in high school. The primary learning objective will be an understanding of the energy resources currently employed to operate human technology, infrastructure, goods manufacture, and services.

Supportive to the above learning objectives is the general concept of energy physics. Students should be able to explain what energy is in a broad sense. This understanding will include the fact that energy is a very extensive concept, and it is defined as the potential of materials and systems to perform useful work. [5] Students will also be expected to know the basic forms that energy assumes, especially those which appear throughout the course curriculum, namely kinetic, potential, thermal, chemical, electromagnetic, and nuclear energy.

The instructional sequence of the unit will also include an overview of energy resources, and students will be able to distinguish between renewable and nonrenewable resources. [6] They will identify which energy resources are considered fossil fuels and describe the processes by which these resources are extracted and used to produce energy. They will learn the environmental burden that unchecked consumption of fossil fuel energy sources is placing on the sustainability of the planet and the need for alternatives to petroleum energy resources. I will also provide a discussion of the main alternative energy sources and their use in California. Those given treatment in this unit include solar, nuclear, wind, hydroelectric, geothermal, and tidal. Class discussions and student research will be used to explore how each resource is used to produce energy, evaluate the advantages and disadvantages of each energy source, and the potential of each to provide energy into the future.

Additional general science methods and skills supported and necessitated by this unit are observation, measurement, calculating unit conversions, and data collection and analysis (computational and graphical). I have also designed scenarios in which students engage in collaboration to identify a problem, conduct research on the defined problem, and synthesize concepts in developing a solution to the problem. The results of their collaboration and research will be used as evidence to provide a critique on a technology or system within a defined sector and design a proposal for mitigating local environmental impact. The final student report will incorporate both written and verbal communication of results.

## Rationale

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> A revolution is on the horizon: a wholesale transformation of the world economy and the way people live. But, this new industrial revolution holds a more important promise: securing the world against the dangers of global warming. [7]

Since the first Industrial Revolution, humanity has been on a one-way track toward increasing reliance upon and depletion of fossil fuel energy resources. This is not only destined to end in the complete exhaustion of these nonrenewable resources, continued conflicts among humans for resource control, and the loss of more species than the planet has seen in the past 65 million years, but also in the devastation of Earth's carrying capacity for its modern burgeoning human population. While the mechanisms and urgency of the consequences of this current global warming trend are still debated, the indisputable truth is that the current trend of fossil fuel use is a primary contributor to this accelerated global warming.

If you are not part of the solution, you are part of the problem. [8]

Solutions to help mitigate the impacts of human-induced global climate change must be adopted at all levels, from industry and policy to institutional and consumer habits. It is important to not only educate my students about the currently understood connection between fossil fuel use and global climate change, as well as the bodies of core knowledge behind this issue, but to also bring awareness to the attainable actions they may undertake to be part of the solution.

### Science-Based Societal Issue

The topic of global climate change carries a considerable economic and political charge; despite the advocacy (mainly publicity and rhetoric) it has received by influential figures in the popular culture, it is not being integrated into the required science instruction that students receive in California public schools. The topic of energy resource consumption and sustainability receives only cursory treatment in our current California textbook and State Educational Standards. I would like to bring a more comprehensive understanding of the various types of hydrocarbon energy sources to my students; moreover, I would like them to receive instruction on the various types and viability of alternatives to fossil fuel consumption.

> The issue of climate change is one that we ignore at our own peril. There may still be disputes about exactly how much we're contributing to the warming of the earth's atmosphere and how much is naturally occurring, but what we can be scientifically certain of is that our continued use of fossil fuels is pushing us to a point of no return. And unless we free ourselves from a dependence on these fossil fuels and chart a new course on energy in this country, we are condemning future generations to global catastrophe. [9]

### Relevance to Students

Looking at the "big picture" can be daunting, whether the news is bleak or the prospects promising. So, the fundamental research unit will be two-fold within the students' sphere of experience and influence; they will examine both their personal habits and those of the school in terms of energy consumption. It is the intention that this unit helps students to become aware of their own energy consumption habits, and glean a sense of personal responsibility and action. Students will assess the energy consumption of their school site and develop a conservation efficiency plan that may be presented to the school and district administration for consideration as described in the Authentic Approach section below. In the interest of the longevity of this unit for subsequent years and its applicability across varied subjects and school sites, an alternate (though admittedly less authentic) hypothetical conservation design plan is also described below.

### Primer to Subsequent Units of Instruction

Certain components of the unit have been designed to deliver content that is fundamental and recurring within the Earth Science curriculum. Energy in the Earth System appears in multiple units, and ensuring students are working with uniform background knowledge instruction regardless of prior knowledge and science instruction. For example, the two sources of energy driving the systems and processes of Earth are the Sun and Earth's core; this fact is among the topics covered in this unit which will also appear in subsequent units of instruction. Another common and recurring topic this unit will introduce is a basic understanding of energy and the various forms of energy. These connections to other units within the course are discussed in the Conclusion and Next Steps section below.

Preparation for advancement to upper level physical science classes is also an aim of this unit plan. This unit will support the purpose of the course itself in providing my students with some common knowledge and core concepts in physical science. Energy is an abundant theme in all fields of science and a fundamental concept that high school students should have learned.

## Student Projects

The acquisition of content background as outlined below is at best tantamount to the research and investigations to be performed by students during this unit. The instructional strategies and the student activities within the classroom will support their individual and group work on both a Personal Energy Consumption Inventory and a School-Wide Energy Audit.

**Individual Assignment: Personal Energy Consumption Inventory**

As part of the introductory set to the Content Background, students will be asked to investigate and analyze their own energy consumption and habits. This could be the very first task that students are asked to complete before direct instruction on the unit's Content Background formally begins.

The first independent activity for students is a personal Energy Consumption/Habits Inventory to identify what activities in their daily routines rely on energy (electricity, food, hygiene, transportation, work/school, and leisure/recreation). The Energy Inventory is designed for students to evaluate their behavioral habits that have the potential for change in an effort to conserve energy resource consumption. Students will qualify their habits by type of activity/description and quantify their energy consumption in terms of hours of charging required by the device; number of appliances plugged into outlets must be listed, with make and model numbers.

The classroom follow up analysis of their data will allow for estimated energy/resource consumption in a typical day. As per classroom activities, data will be pooled and average energy consumption per student determined, then multiplied by the number of students in Jefferson High School, the District, the County, California, and the United States to see the impact of the cumulative effects of common individual habits. Each student works individually on a personal energy conservation plan with very clear actions and pledge or conservation goal.

You must become the change you wish to see in the world. [10]

**Group Project: School-Wide Energy Audit**

I plan on introducing a School-wide Energy Audit and conservation challenge after students have performed their own Personal Energy Inventory. Each student is part of a team assigned to (1) participating teachers and/or (2) designated sectors of campus as appropriate for the school site and grouping of students. Teams assess the power consumption (kWh) in each classroom and their assigned sector of campus to identify where energy inefficiencies are greatest, and then work out a plan for (1) teachers' classrooms and (2) the school to reduce energy consumption and improve efficiency. The group's final task is to draft a proposal for either a hypothetical or authentic campus green energy project.

> Never doubt that a small group of thoughtful committed citizens can change the world. Indeed, it is the only thing that ever has. [11]

*Hypothetical Approach*

Student groups design plans for "greening" the school. Students first identify target areas that need improvements in energy efficiency (see the sectors identified below) and propose possible solutions. Case studies can be used to help students generate ideas and designs for implementing new infrastructure. Examples may include, but are not limited to, sites for additional solar panel installations, green rooftops, renovations to the transportation options and parking lot design, improved and increased recycling receptacles, and establishing school composting to complement the existing school garden boxes project.

*Authentic Approach*

This may be more challenging, as it requires obtaining information from the school or district accounting, as well as a clear method of quantifying the energy consumption within each sector. In the authentic approach, students will design plans to reduce their school's actual "energy budget" within the following sectors: Food (including food items and options, cafeteria facilities and practices, food service materials, and food waste); Transportation (such as school buses, student and family automobiles, faculty and staff modes of transport); and the lighting and electric consumption per classroom will be measured and evaluated by students in order to provide actions and steps to reduce the current amount. For possible solutions and action plans, see the Energy Conservation in Schools section in Appendix B: Further Resources and Readings for Students and Teachers.

The most accessible aspect of either of the above approaches will be the data collection for lighting and electrical usage in each classroom, office, and computer lab within the school. Students may identify their own workspace within the school to monitor or be assigned in groups. The initial task will be to use an electricity usage monitor to assess the consumption in the various working spaces on our school site. [12] Students will then work in teams and in collaboration with the teacher or staff member assigned to each given workspace. The goal is to assess the initial energy consumption and then develop a plan to reduce that amount. This could be made into a competition to see whose assigned workspace reduces its electrical usage by the greatest amount.

## Content Background and Sequencing

The unit will be divided into a series of instructional blocks, beginning with the most basic and fundamental science skills and concepts and progressing concurrently with instruction and data collection for the culminating project described above. The focus of the unit is an energy conservation plan developed by students in which they will utilize the background knowledge provided in the sections below. The core science concept of energy will begin the unit and will act as a springboard for a more informed and in-depth look at the various ways that objects and systems in Earth Science utilize and produce energy; and, ultimately, students will examine ways in which energy sources are utilized for the needs of human societies.

The background information below will be delivered to students in order to provide content knowledge and relevance to their own research, energy audit projects, and culminating reports. This background information may be delivered concurrently with the students' work and may serve to broaden their scope of understanding, but it will not constitute the primary objective of the unit. The background information provided below does not represent exclusive student learning objectives; rather, it is provided for limited use insofar as it is needed to assist students in accomplishing the project goals outlined in the Student Projects section above. The content background described below is also designed to meet the expectations of the Standards-based curriculum as set forth by the state as well as within our district (see Appendix A:

Implementing District and State Standards).

**Introduction to Energy Physics**

The first topic introduced in the unit could itself be a "mini-unit" covering a general overview of Energy. For the purposes of this unit, however, it will be covered over the course of two to three days of direct instruction. Energy can be understood from an experiential point of view by virtually everyone. The ways in which we may describe energy may range from running around the track and kicking a soccer ball to boiling water, turning on the lights, and re-charging our mobile electronic devices. But, these are all ways in which energy is used or converted from one form to another. The definition of energy given by classical physics is the ability of an object or system to do work on another object or system. [13] Here it will probably be helpful to define or discuss with students what is meant by the terms "object" and "system." Additionally, a small amount of instruction on how work is defined could also be provided; however, as this is not the emphasis of the unit or even within the scope of the course curriculum, it will be given only brief attention here if at all. [14]

*Types of Energy*

Energy is not a thing, rather a condition or state of being of a thing. That energy may present in different forms often assists in students' understanding of it as a quality or characteristic of an object or system, and not the object or system itself.

The basic forms of energy include: kinetic, potential, thermal (heat), chemical, electrical, electrochemical, electromagnetic, sound, and nuclear. Only the forms of energy that I will introduce to my students will be very broadly defined here. Kinetic (also mechanical) energy is the energy possessed by an object due to its motion; this becomes significant within the unit instruction on the generation of energy by a turbine. Potential energy is the energy stored in an object due to its gravitational relationship with Earth. Thermal energy, or heat, is a result of the kinetic energy of the particles an object contains. Chemical energy can be described as a microscopic form of potential energy; chemical energy results from the electric and magnetic attractions of particles within matter, and it can be released or converted when particles are rearranged in chemical reactions. Electrical energy is the result of the flow of an electrical charge through a conductor; it exists as a result of a chain of repulsive interactions between electrons within a metal wire conductor when voltage is applied. Electrochemical energy is also a form of potential energy, such as that stored in a battery. Electromagnetic energy can be described as the energy of "light," and it travels as both a particle, called a photon, and in different wavelengths that correspond to the colors of the spectrum. Sound energy travels as compression waves through the medium of air. Nuclear energy is the result of interaction within or among atomic nuclei; this form of energy becomes significant both within the unit discussion of the use of nuclear energy to produce electricity and beyond the unit when students study the energy created within stars as well as from the Earth's core.

*Converting Units of Energy*

Converting among different systems and units used to measure any quantity is an important science skill for students. The following table of Common Energy Unit Conversions will be useful as either background for the teacher, a resource for students, or both. [15]

Common Energy Unit Conversions

| Convert To: | Terajoule (TJ) | Gigacalorie (Gcal) | Megaton Oil (equiv) (Mtoe) | Million British thermal units (Mbtu) | Gigawatt-hour (GWh) |
|---|---|---|---|---|---|
| Convert From: | Multiply By: | | | | |
| TJ | 1 | 238.8 | 2.388x10-5 | 947.8 | 0.2778 |
| Gcal | 4.1868x10-3 | 1 | 10-7 | 3.968 | 1.163x10-3 |
| Mtoe | 4.1868x104 | 107 | 1 | 3.968x107 | 11630 |
| Million BTU | 1.0551x10-3 | 0.252 | 2.52x10-8 | 1 | 2.931x10-4 |
| GWh | 3.6 | 860 | 8.6x10-5 | 3412 | 1 |

**Energy in the Earth System**

Energy in the Earth system will receive a general overview for the purpose of returning to this theme in future units, and ensuring that students will have the same content background, regardless of prior knowledge and science instruction. The two sources of energy driving the systems and processes of Earth are the Sun and Earth's core.

The Sun produces its own energy and this energy radiates, or moves outward in all directions from the Sun. Collectively referred to as solar radiation, the energy produced by the Sun reaches Earth in the form of thermal, or heat, energy as well as electromagnetic energy including the visible spectrum and ultra-violet (UV) radiation. It may be helpful for student understanding to address misconceptions regarding the use of the term "radiation"; many students perceive this terms as indicative of something harmful, which is not necessarily the case. Rather, radiation is the process of emitting radiant energy or the energy itself that is being radiated. Solar radiation provides the energy for all processes and systems occurring within Earth's atmosphere and at Earth's surface.

The Earth's core produces is own heat energy which is converted from the nuclear energy of spontaneous radioactive decay of isotopes within the core. This heat energy is then conducted into the mantle where it is transferred via mantle convection to the overlying lithospheric plates. The internal energy from Earth's core may ultimately be harnessed as geothermal energy. The internal heat of the planet results in volcanic activity and areas of high subsurface temperatures that create reservoirs of steam and hot water that may be used to directly drive turbines and create electricity. This and other alternative and renewable energy resources are further discussed in the section below.

**Energy Resources**

A resource is a raw material obtained by humans to produce or achieve necessary or desired goods or results. Energy resources are utilized for generating the power for human infrastructure and technology and, in general, make possible our "ways of life"; energy resources are what we use to cook our food, make our clothing, listen to our music, and drive to work or school. Energy resources can be broadly categorized as renewable and nonrenewable. A renewable resource is one that can be replenished within a relatively short period of time, such as months, years or decades; a renewable resource is available, accumulates or grows in a useable or harvestable quantity within the timespan of sustained use. In contrast, nonrenewable resources take millions of years to form or accumulate [16] ; these resources exist or are available in limited supplies or reservoirs and can be exhausted through sustained use.

*Hydrocarbon Energy Sources: Nonrenewable Resources*

Students will receive instruction on petroleum energy sources. They will be given definitions for each of the following: Additionally, instruction will include how and where these energy sources are formed on Earth; the extraction methods and related hazards; the production and uses of energy from fossil fuels as well as the consequences involved in said production and use; and finally a discussion of the sustainability of these energy sources should be provided.

Fossil fuels are broadly defined as any hydrocarbon that may be used as a source of energy. Fossil fuels are named such because they form over millions of years. Because fossil fuels will not be replenished within a short amount of time (namely, a human lifespan), they are considered to be nonrenewable energy resources. This makes them a topic of considerable concern and conflict among human societies. Fossil fuels include coal, oil, and natural gas.

Coal is formed when decayed plant material accumulates, is buried under more material, and is subjected to continued heat and pressure within Earth's crust. Most power plants use coal to generate electricity by burning the coal. There four stages in the development of the type of coal that is generally used to create electricity in power plants. Each stage requires more heat and pressure to transform the plant material into a metamorphic rock, called anthracite. The coal contains a large amount of energy that is released in the form of heat when it is burned, which is used to create steam and piped at high pressure to turn turbines and produce electricity. Coal has a number of drawbacks, including the hazards of mining, as well as the air pollution and acid rain that result from the high sulfur content of coal.

Petroleum (simply called oil) and natural gas also form over millions of years from the decaying remains of plants and animals buried at the bottom of ancient oceans. Chemical reactions convert this solid matter into liquid and gaseous hydrocarbons which are gradually "squeezed" out of the sedimentary rocks that contained them; water is also forced out of the rock layers with the oil and gas. The oil and gas will continue to move up within permeable rock layers, and rise above the water due to their lower density. Oil and natural gas wells are drilled into a cap rock that stops the upward movement of these materials to the surface. Oil wells can be drilled into continental or oceanic crust, and the hazards of drilling include potential injury or death to workers, as well as spills and explosions from these highly flammable, pressurized, and explosive hydrocarbons.

*Alternative and Renewable Energy Sources*

The terms alternative and renewable are often used synonymously. However, the term alternative could include fossil fuels that have not been in conventional or widespread use; whereas, the term renewable would not include any type of fossil fuel. A renewable energy source is one that can be replenished, harnessed, or regrown over a relatively short period of time (usually years and decades, or within a human life time). Examples of renewable energy sources include solar, wind, hydroelectric, and geothermal. Tidal power and nuclear power are also alternative energy sources that will be introduced to students in this unit.

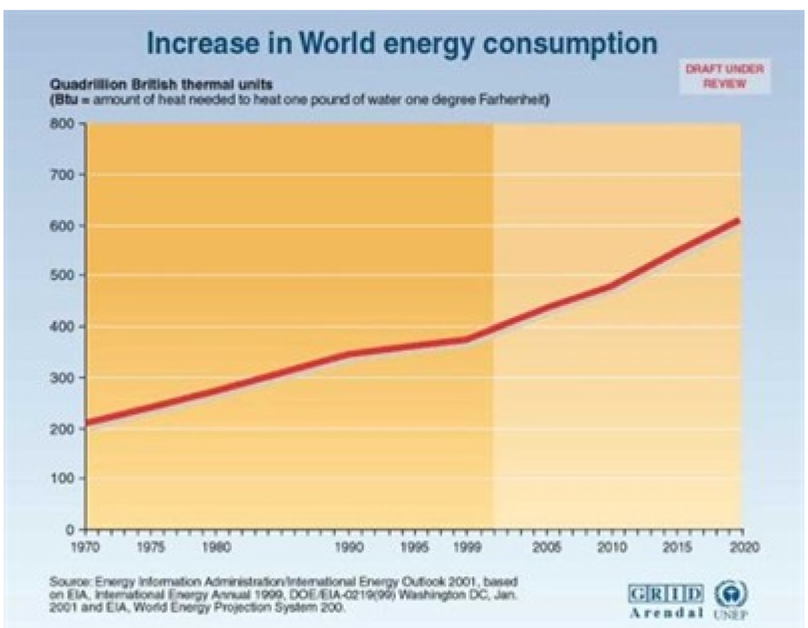
> By employing the intelligence of natural systems, we can create industry, buildings, even regional plans that see nature and commerce not as mutually exclusive but mutually coexisting. – Brad Pitt [17]

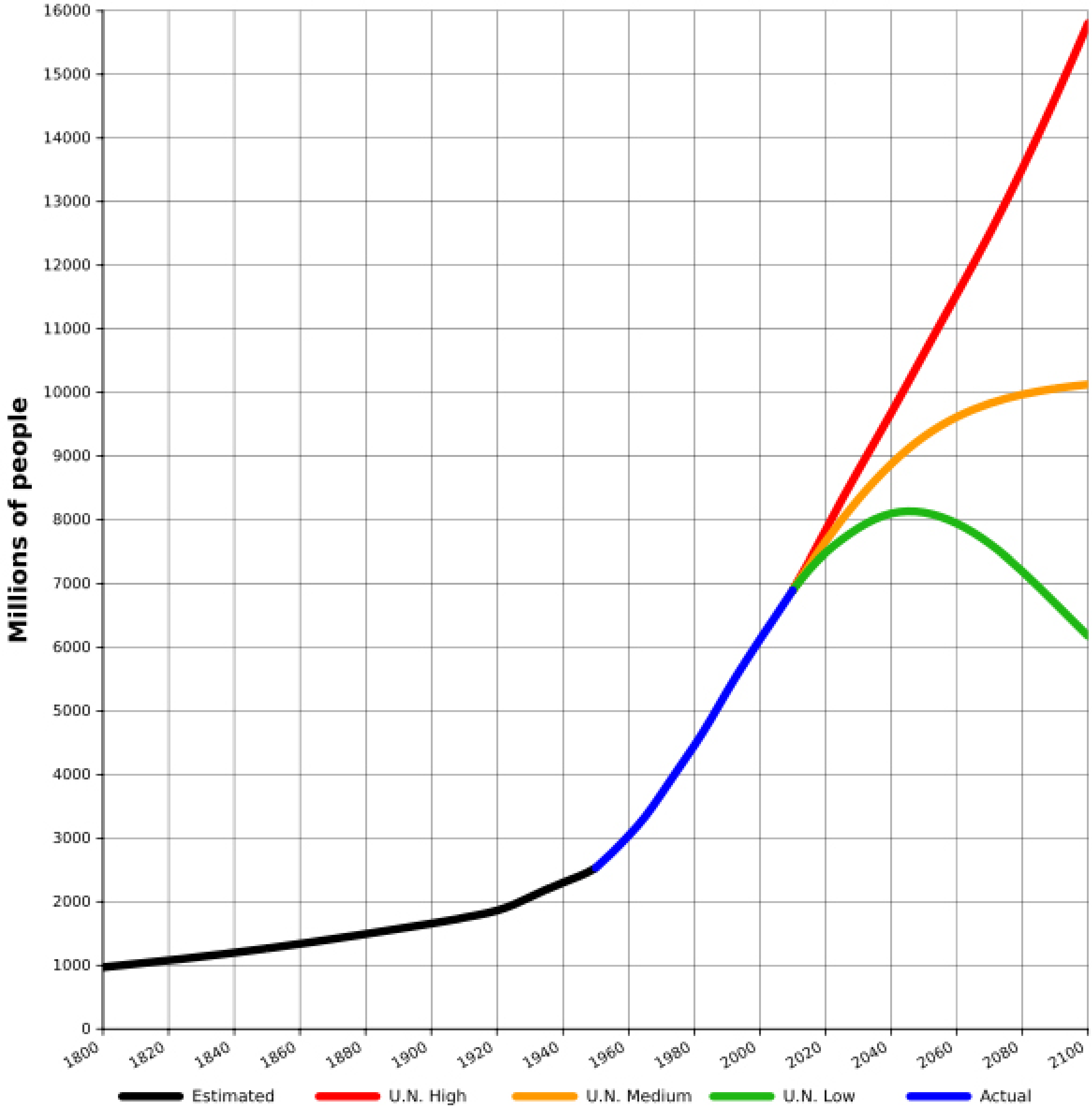
Instruction returns to the topic of solar energy here within the explicit context of renewable energy resources. Solar energy is the most abundant, although not the most accessible, energy resource in all regions of the world or United States. Solar power is collected by photovoltaic cells that convert the sunlight directly into electricity. Wind energy will receive attention within the local context (there are extensive wind farms across central California; many of which the students have seen, and that experience will lend relevance to this topic). Although wind looks promising, the current technologies are in need of improvement; there is public concern over noise pollution and harm to local bird species; and the cost and objections to use of large tracts of land in populated areas hinder development of this energy resource.

Although alternative energy sources to fossil fuels exist there are myriad obstacles to their wide spread use. While solar energy is "free" and nonpolluting, the equipment used to harness this energy can be quite costly and involve materials that are toxic and not easily disposed of or recycled. Wind is in need of technological and infrastructure development. Nuclear power has very evident drawbacks (such as the toxicity exposure threat to employees and disposal of waste) and safety hazards to surrounding communities (including evacuation and emergency response and the spread and persistence of contamination), as experienced in many examples throughout human history, including the recent disaster at Fukushima. There is not going to be a "one size fits all" solution to transforming the energy industry, but employing these alternatives in viable locations should become common policy and practice. The United States has some catching up to do compared to other countries such as china and India in use of renewable energy sources. [18]

**Human Energy Consumption: Trends and Habits**

Human energy consumption will be examined next in the unit instruction. Students will be given statistical data and analyze graphical information about trends in human energy consumption. We will look at the various ways in which humans use energy and the sectors that consume the most energy. Energy consumption by source will also be studied. See the graphs included in Appendix B: Further Resources and Readings for Students and Teachers. Skills in basic graphical analysis such as identifying trends displayed by graphs could also be supported with content specific graphs. Side by side correlation of graphical data could lead students to develop their own questions and form hypotheses, such as in the relationship between world energy consumption [19] and population growth [20] as shown below.






Energy Conservation and Efficiency

Why do we need to conserve our energy sources? Answers to this question may be generated by students or given as prompts in class discussion and debate. It may be useful at this point during instruction to define the terms *conservation*, *efficiency*, and *sustainability*, as these are often used in discussions relating to energy consumption but rarely defined or considered independently of one another. Among the reasons to promote energy conservation and efficiency is the fact that our reliance on nonrenewable fuels may not see an easy or fast end; and, carbon emissions leading to global warming and its consequences threaten human populations as well as other species inhabiting this planet. Additionally, fossil fuels need to be used sparingly due to pollution and the risks to human health, the hazards of extraction, and the potential of these limited resources to provoke more warfare. It would be compelling for students to explore how the world will change and what challenges and solutions will arise in the face of a population that is set to exceed 9 billion by 2045. [21] See Appendix B: Further Resources and Readings for Students and Teachers for a sample of the Consumption Cartogram and reference information.

What is energy efficiency? This question will be answered via direct instruction and will draw on the work of

Maximillian Lackner (Energy Efficiency). Students will also be led to the answer to such questions as: Where do energy inefficiencies exist and what are some strategies at the personal, local, national, and global level that may reduce these inefficiencies?

What is energy conservation? Energy conservation will be compared and contrasted with energy efficiency. Again, the strategies that may achieve energy conservation at the personal, local, national, and global level will be explored. For specific personal and institutional strategies that the students may propose and carry out, see the section on Energy Conservation in Schools in Appendix B: Further Resources and Readings for Students and Teachers.

What are the prospects for achieving a sustainable energy future? What can individual changes in habits really accomplish? What are some of the success stories (case studies, models)? Further research questions will conclude the unit's instructional aims and guide the students in framing the culminating report of their School Energy Audit.

## Instructional Strategies

The unit may begin with a written Background Knowledge test, which students may later use to self-assess what they learned throughout the unit; this also serves the important purpose of informing instruction and strategically grouping students, based on extent of prior content knowledge. Before direct instruction on each sub-topic within the unit, students will be provided the opportunity to express and share their own ideas.

The intended brainstorming strategies include the "Know-Want-Learn" (KWL) Charts, in which students list in three different columns what they know already (K) want to know (W), and are learning (L) on a topic; the "Warm-Up Whip," a one or two word quick share in which each student presents ideas or answers a prompt in succession around the room; "Think-Pair-Share" prompts which ask the students to first think (and usually write) about their ideas on a topic or question, then exchange ideas with a partner; and, a structured dialogue format called a "Diad," which requires students to hold the space for a given amount of time during which only one partner speaks without interruption while the listener is attentive and practicing appropriate body language.

I will also incorporate several short video clips into the direct instruction of this curriculum unit to provide visual context as well as promote interest in the topics, such as video footage of South Pacific (e.g., Bikini Atoll) nuclear testing. Video will also be used to show the forms of energy, fossil fuel consumption and consequences, alternative energy resources, The Story of Stuff, and National Geographic's 7 Billion; all of these videos can be found on a search of YouTube, and if carefully reviewed this particular site often provides succinct, brief, and entertaining video clips to supplement instruction.

Direct instruction will also include Power Point Presentations: (1) for the introduction to energy and its various forms, (2) on the types of energy resources discussed in the unit, and (3) to introduce ideas on energy conservation and efficiency. Students are provided with slide handouts to follow during PowerPoint presentations and they are held accountable during the presentation with an assignment to "Talk to the Text," which is an interactive style of note taking (literacy strategy) wherein students write their own ideas, connections, and questions within the spaces and margins around the given text. In addition, "Talking to the

Text" on a PowerPoint handout requires students to make note of the supplemental verbal information, provided by the instructor, beyond that stated within the slide content. Independent student work will include reading and notes from text sources, including critical thinking, opinion summaries, and debate. I will also be providing news and scholarly articles for students to use in a group-learning format known as a "Jigsaw."

Classroom activities for students should be chosen to support the work that they are asked to complete individually and for the culminating School Energy Audit. Additionally, classroom activities will serve to support the background content knowledge as outlined in the above sections. Such activities may include labs and hands-on investigations, as well as independent research. Labs and investigations may include observing the various forms of energy such as heat, light, electrical, potential, and kinetic. Data collection will be practiced in a simple experiment of heating water and using the increase in temperature to determine an estimate of total solar output (kJ); data collection and analysis will also be emphasized in students' individual energy audits and practice reading electric meters.

While time constraints may not permit this in my delivery of the unit content, students may be required to conduct additional text and web-based research on a given energy resource (both petroleum-based and alternative) and work either independently or in small groups to produce a final product in presentation format and teach and learn from each other, in lieu of direct instruction by the teacher on these aspects of the unit Content Background.

## Conclusion and Next Steps

The follow-up on actions taken and administrative response to students' proposals should occur within the current grading period, and continue on a regular basis at least once within each subsequent grading period. This will give the students a sense of purpose to their work, and an insight and experience with the diligence that is needed to change the current trends and infrastructure that may be dominant and resistant to change.

I addition to the above logistical follow-up on the students' unit-culminating proposals, the content will also reappear in subsequent units. Topics that will draw on the background knowledge of types of energy will be: the study of seismic waves (accumulation and release of elastic energy); mechanism for plate tectonics (heat energy transfer via radiation from the core and mantle convection); electromagnetic and sound energy are discussed in the study of distant bodies in space and the use of optic, infrared, and radio telescopes; nuclear energy of fusion within the sun and radioactive decay within Earth's core; kinetic and potential energy will appear during instruction in Astronomy as applies in the law of universal gravitation and the orbits of planets around the sun and satellites around planets; and, chemical energy may be taught within the study of biogeochemical cycles (e.g., photosynthesis and the carbon cycle).

Finally, topics from this unit will return during the culminating unit of instruction for the year. I complete the year-long study of Earth Science with instruction on Climate Change and Global Warming. The very clear connection with this unit is the correlation between the burning of fossil fuels with the excess atmospheric carbon dioxide. Students will be encouraged to draw on their understanding of fossil fuels and the alternative energy sources in discussions on both the causes of and possible solutions to the current accelerated global warming trend. In this way, the unit described in this narrative will serve as a building block to establishing one of my instructional goals for the course, which is to promote my students' critical thinking and conscious choices as consumers of both materials and ideas in their lives beyond the classroom.

## Appendix A: Implementing District and State Standards

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District

Jefferson Union High School District (JUHSD) has an established pacing guide for Earth Science curriculum, which teachers of the course are expected to follow. This pacing guide can be found on the JUHSD website. The topic from the pacing guide that is supported by this unit is the California Mineral, Energy and Soil Resources within the unit on Earth's Materials.

State

The following are from the Science Content Standards for California Public Schools, 2000.

- Energy in the Earth System: (4a) Students know the relative amount of incoming solar energy compared with Earth's internal energy and the energy used by society, and (6d) Students know how computer models are used to predict the effects of the increase in greenhouse gases on climate for the planet s a whole and for specific regions.
- *Biogeochemical Cycles:* (7b) Students know the global carbon cycle: the different physical and chemical forms of carbon in the atmosphere, oceans, biomass, fossil fuels, and the movement of carbon among these reservoirs.
- *California Geology:* (9a) Students know the resources of major economic importance in California and their relation to California's geology.
- *Investigation and Experimentation:* (1a) Select and use appropriate tools and technology...to perform tests, collect data, analyze relationships, and display data, (1d) Formulate explanations using logic and evidence, (1i) Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena, (1k) Recognize the cumulative nature of scientific evidence, (1l) Analyze situations and solve problems that require combining and applying concepts from more than one area of science, (1m) Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include...choice of energy sources...in California.

Newly Proposed Standards

Among the above traditional and still currently followed standards, the proposed Next Generation Science Standards (NGSS) are currently in the revision phase for a second draft. These new standards directly address human behavior and environmental issues, as well as engineering and technology links. In the event that these standards are adopted, this curriculum unit addresses the following performance expectations from the May 2012 Draft of the NGSS.

HS.ESS-HS *Human Sustainability* (b) Reflect on and revise design solutions for local resource development that would increase the ratio of benefits to costs and risks to the community and its environment, (f) Identify mathematical relationships using data on the rates of production and consumption of natural resources in order to assess the global sustainability of human society, and (g) Construct arguments about how engineering solutions have been and could be designed and implemented to mitigate local or global environmental impacts.

HS-ETS-ETSS *Links Among Engineering, Technology, Science, and Society* (c) Analyze data to compare different technologies designed to accomplish the same function regarding their relative environmental impacts, costs, risks, and benefits, and what may need to be done to reduce unanticipated negative effects, and (d) Construct or critique arguments based on evidence concerning the costs, risks, and benefits of changes in major technological systems related to … energy … needed to support a growing world population.

## Appendix B: Further Resources and Readings for Students and Teachers

**Websites for Basic Energy Physics & Energy Resources Background Information:**

http://www.nmsea.org/Curriculum/Primer/energy_physics_primer.htm

- Basics on energy in a conceptually deep but mathematically simple way

http://www.energyeducation.tx.gov/energy/section_1/topics/index.html

- Very accessible language, investigations/activities, web resources

http://www.eia.gov/kids/index.cfm

- Using and saving energy, history of energy, games and activities

Just for fun… may be used for catching interest & intro:

http://www.youtube.com/watch?v=z7lCkQV7GEE&feature=related

- made by students, incorporates music and pop culture references

**Organizations:**

ACE Alliance for Climate Education

Alliance to Save Enegry

Energy Quest Room

NC4K

Captain Planet

Eco Kids

EERE Kids

PG&E

Union of Concerned Scientists

**Government Reports:**

International Energy Outlook 2011

http://www.eia.gov/forecasts/ieo/

**IEA Energy Statistics Manual**

***www.****iea*.org/**stats**/docs/**statistics_manual**.pdf

**Information on Renewable Energy Resources in general:**

http://www.nationalatlas.gov/articles/people/a_energy.html

http://www.darvill.clara.net/altenerg/index.htm

http://www.eia.doe.gov/kids/

Go back and find original source (NO WIKIs)

http://en.wikipedia.org/wiki/Intermittent_energy_source

**Fossil fuels:**

http://www.energyquest.ca.gov/story/chapter08.html

http://www.darvill.clara.net/altenerg/index.htm

http://www.eia.doe.gov/kids/

**Amount of energy used in California and USA and the World:**

http://www.grida.no/graphicslib/detail/trends-in-energy-consumption_2a09

www.careenergy.com

*Click on powering America

*Click on State Profiles and Select California

http://bbhhive.com/2010/08/the-average-americans-annual-energy-consumption/

The Story of Stuff 20 minute video

http://www.youtube.com/watch?v=9GorqroigqM

Soylent Green – Science fiction plot that depicts challenges of an over-populated world

http://www.imdb.com/title/tt0070723/plotsummary

**E-book & Article Links**

Integration of Alternative Sources of Energy

By Felix A. Farret, M. Godoy Simões

http://books.google.com/books?id=a8BJ3zYYd3MC&printsec=frontcover&source=gbs_ViewAPI#v=onepage&q&f=false

Population Peril, LA Times

http://www.latimes.com/news/nationworld/nation/wire/sns-mct-editorial-population-peril-20120817,0,636718.story

**Energy Conservation in Schools:**

Resources: Energy Saving Tips for Schools, Kentucky Energy and Environment Cabinet

http://energy.ky.gov/resources/Pages/TipsforSchool.aspx

More information can be found at the Alliance to Save Energy's Green Schools Web site.

Schools: An Overview of Energy Use and Energy Efficiency Opportunities

http://www.energystar.gov/ia/business/challenge/learn_more/Schools.pdf, provides resources and strategies for approaching schools and districts to adopt changes…

Fact Sheet: Saving Energy in Schools

http://www.nrdc.org/greensquad/library/energy_use.html, offers tips on what kids can do and what schools can do…

**Related Fact Sheets**

Solar Energy in Schools

Schools, Lighting and Daylight

**For more information** The Energy Efficiency and Renewable Energy's kids page

The EERE's *Energy Information for your School*

Calif. Energy Commission's education page

The Appliance Olympics

Power$mart: Easy Tips to Save Money and the Planet

Print Texts and Publications:

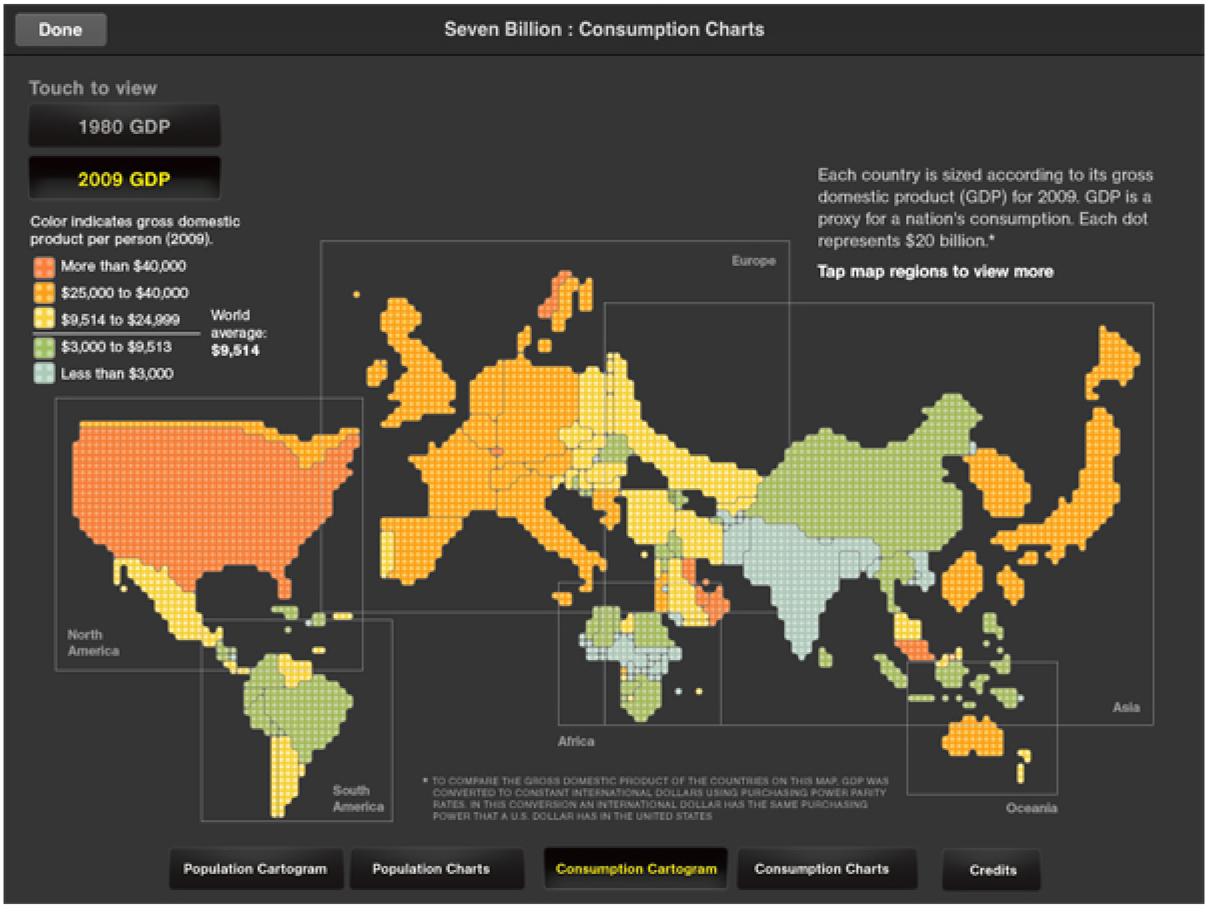
Kruger, Paul. *Alternative Energy Resources: The Quest for Sustainable Energy*

Discover Magazine issues for student reading: September 2009, December 2009, May 2010, June 2010, October 2010, January/February 2011, and January/February 2012

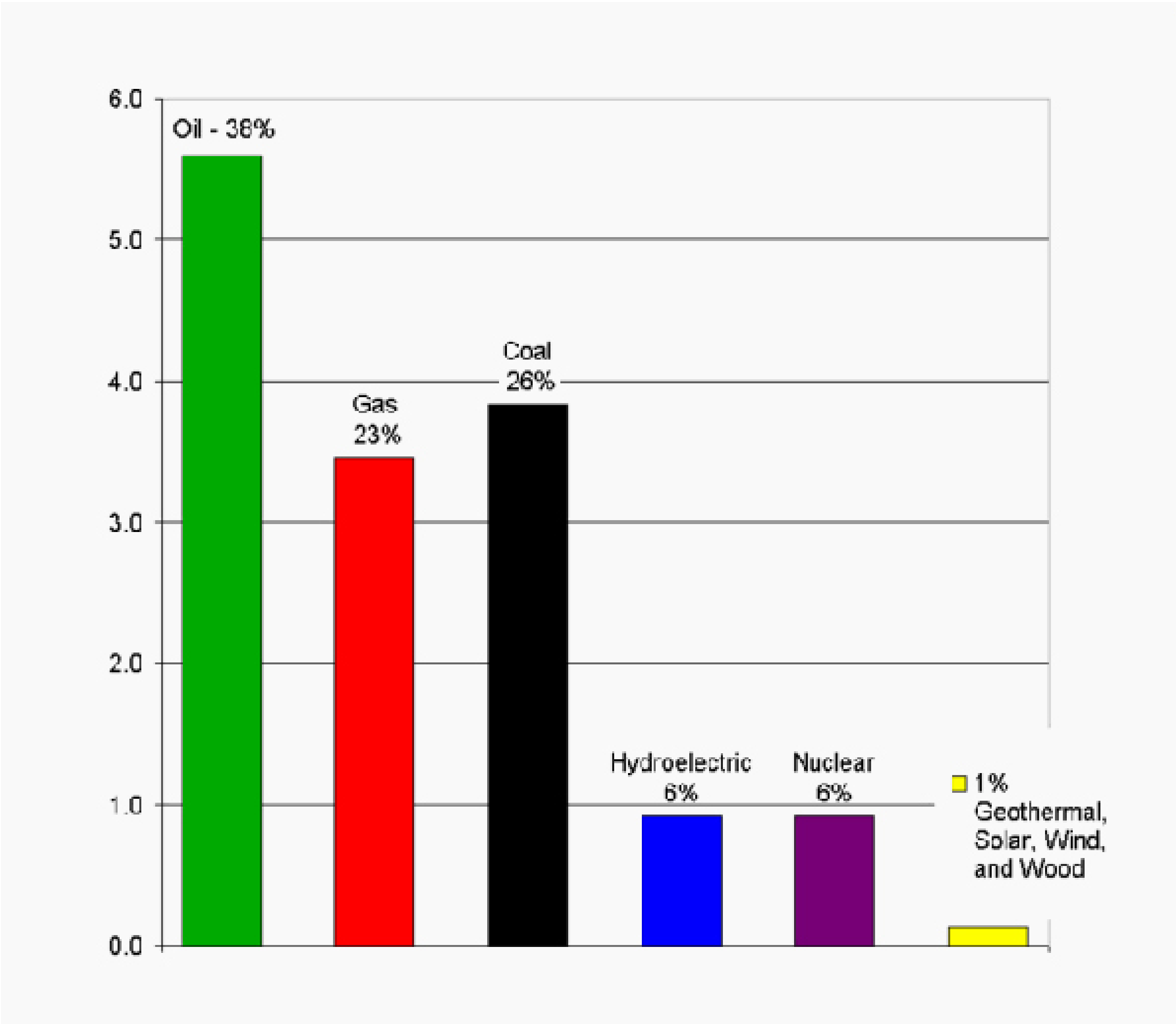
Smithsonian Magazine, Special 40 th Anniversary Issue

Nature Conservancy Magazine, Autumn 2009

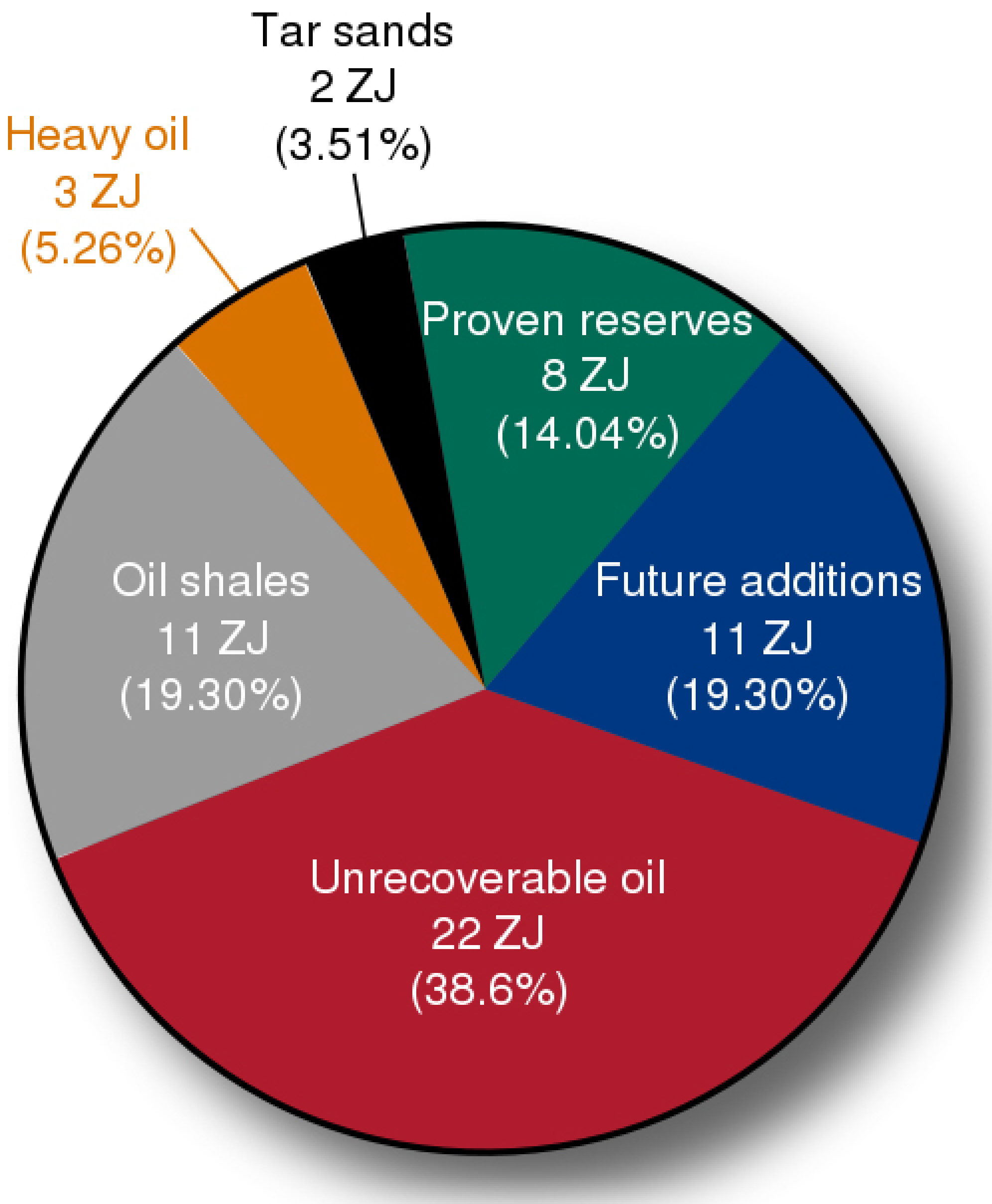
**Graphs and Data:**



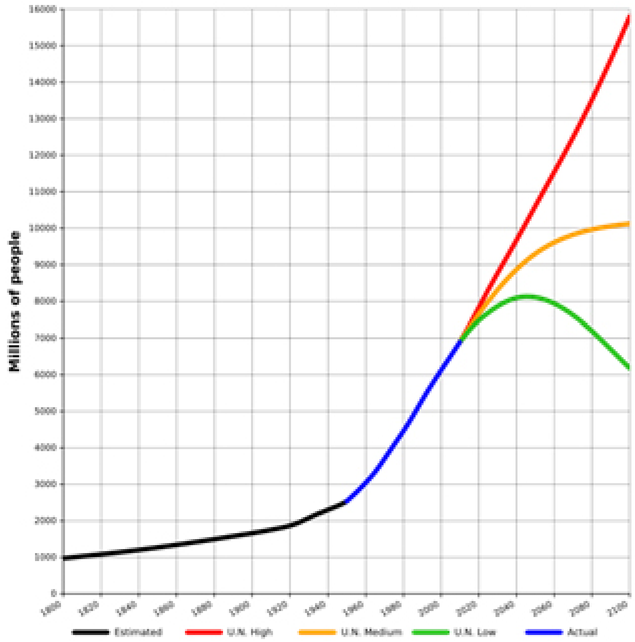

http://ngm.nationalgeographic.com/7-billion; this consumption cartogram and other interactive graphic material can be found in National Geographic's exploration of what the growing world population will look like and the challenges that will be faced.



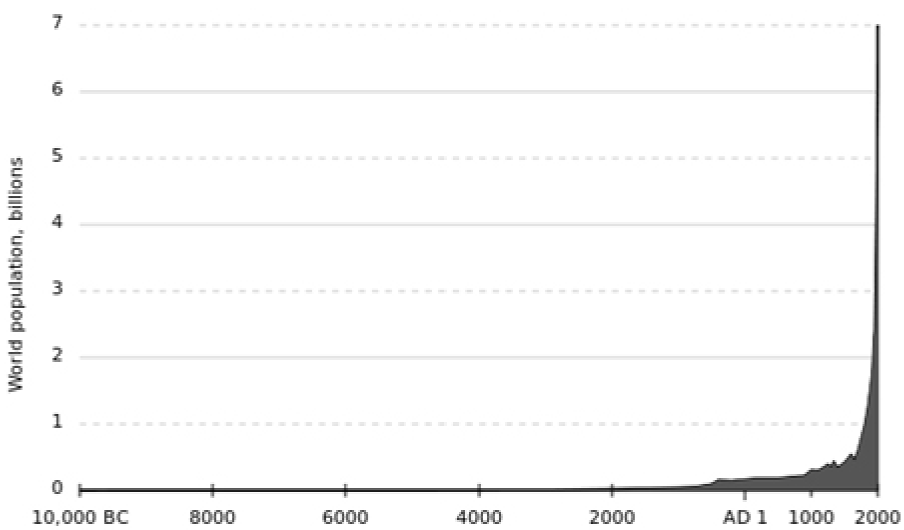

2004_Worldwide_Energy_Sources_graph.png for historical comparisons...




Breakdown of the remaining 57 ZJ of oil on the planet. Annual oil consumption was 0.17 ZJ in 2004, Author: Frank van Mierlo (source image), Scott Nazelrod (SVG)



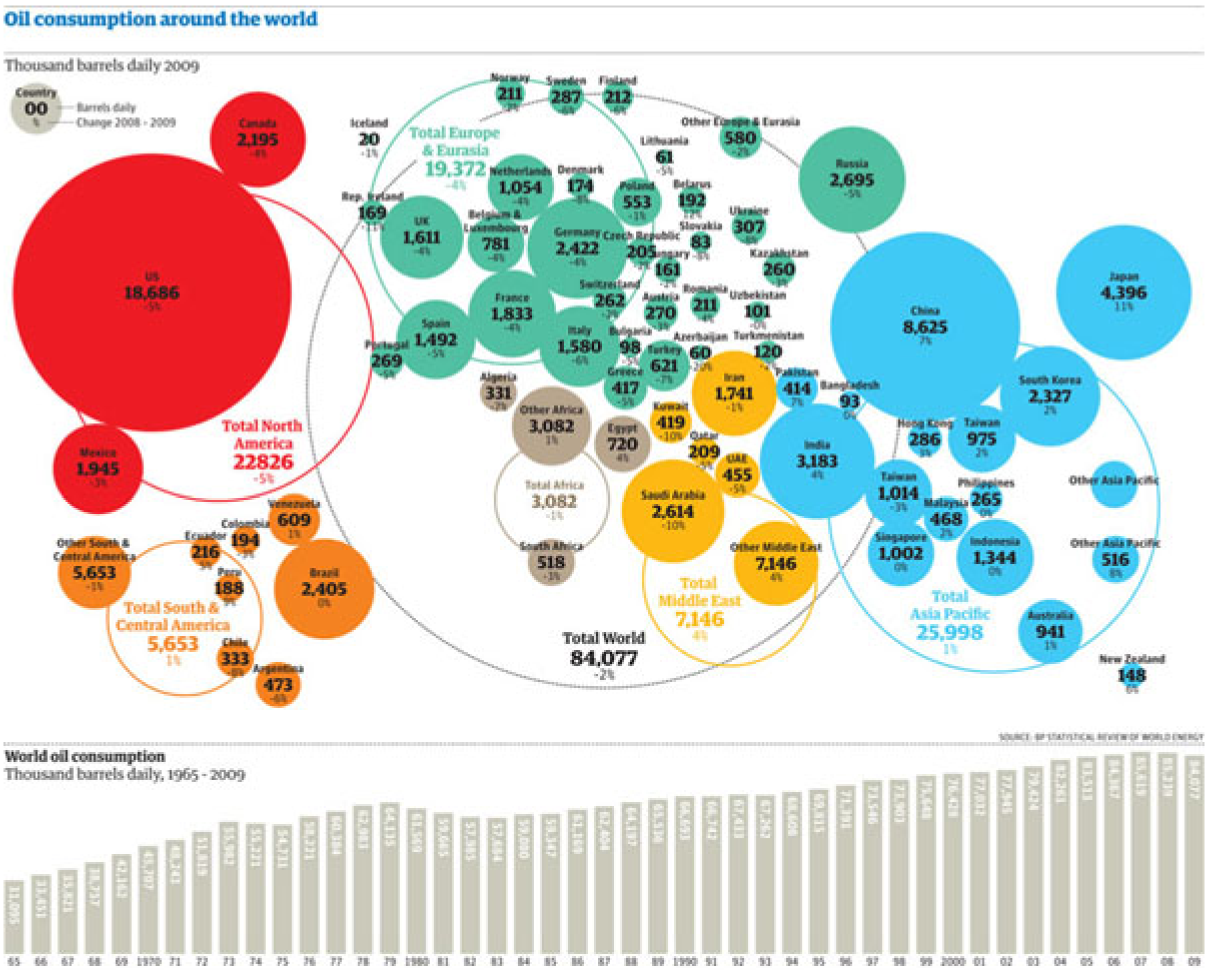

World population from 1800 to 2100, based on UN 2010 projections and US Census Bureau historical estimates.}} |Source =based on file:World-Population-1800-2100.png,




World human population (est.) 10,000 BC–2000 AD; The data is from the "lower" estimates at census.gov.

- United Nations, 1999, The World at Six Billion, Table 1, "World Population From" Year 0 to Stabilization, p. 5, http://www.un.org/esa/population/publications/sixbillion/sixbilpart1.pdf

- U.S. Census Bureau (USCB), 2008, "Total Midyear Population for the World: 1950-2050", Data updated 12-15-2008, http://www.census.gov/ipc/www/idb/worldpop.html




BP Statistical Review of World Energy

## Bibliography


Bruton, Sheila and Ong, Fae, eds. Science Content Standards for California Public Schools. Sacramento, California: California Department of Education, 2000.

Farret, Felix and M. Godoy Simoes. Integration of Alternative Sources of Energy. Hoboken, New Jersey: John Wiley & Sons, Inc., 2006. Distinguishes between Alternative and Renewable energy sources; fundamentals, technology, and integration of sustainable alternatives are discussed from engineering to end-user.

Garnier, Jean-Yves. IEA Energy Statistics Manual. OECD/IEA, 2005. This is a detailed document containing recent data as well as background content for analysis of energy statistics.

Kruger, Paul. Alternative Energy Resources: The Quest for Sustainable Energy. Hoboken, N.J.: John Wiley, 2006. Offers philosophical questions, historical perspectives and trends in energy consumption, including the fossil fuel era and the sustainability of various energy resources and alternatives to fossil fuels.

Krupp, Fred and Miriam Horn. Earth: The Sequel. New York: W.W. Norton & Co., 2008. Offers an optimistic look at the alternative resources and technologies for a sustainable energy future, and provides a comprehensive list of online resources for further up-to-date information.

Michaelides, Efstathios. *Alternate Energy Sources.* Berlin: Springer, 2012. Provides a definition and units of energy in preface to a very current discussion of energy supply and demand, as well as comprehensive treatment of alternative energy sources.

National Research Council, National Science Teachers Association, American Association for the Advancement of Science, Achieve (collectively, the Strategic Partners Group). *Next Generation Science Standards*, www.nextgenscience.org/next-generation-science-standards/ (May 7, 2012 Draft)

Tarbuck, Edward J., Frederick K. Lutgens, and Dennis Tasa. *Prentice HallEarth Science*. Needham, Mass.; Upper Saddle River, New Jersey: Pearson/Prentice Hall, 2006. This is the current textbook for ninth grade Earth Science, adopted by Jefferson Union High School District in 2006.

## Endnotes

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1. John Wargo, YNI Seminar: *Energy, Environment and Human Health*, discussion notes
2. John Lennon, Musical Artist; from the song, "Imagine"; this quote and those indicated by notes #8, 9, 10, 11 and 17 below are included here because they will be used to generate student interest and classroom discussions
3. Jefferson High School Accountability Report Card, 2010-2011, http://jefferson.schoolwisepress.com/home/site.aspx?entity=23449&year=2011
4. Jefferson High School Profile 2011-2012, http://jhs.juhsd.net/pdf/Jefferson_School_Profile_2011-2012.pdf?entity=23449&year=2011
5. E. E. (Stathis) Michaelides, *Alternative Energy Sources*, 2
6. Tarbuck and Lutgens, *Prentice Hall Earth Science*, Ch. 4; this is the chapter on energy resources in the student textbook, and it will be supplemental to content that I deliver on this topic
7. Fred Krupp, *Earth: The Sequel*, 3
8. Eldridge Cleaver; see explanation from #2
9. Barack Obama, President of the United States; see explanation from #2
10. Mahatma Gandhi; see explanation from #2
11. Margaret Meade (1901-1978), U.S. Anthropologist; quote context and origin unknown; see explanation from #2
12. Electricity usage monitors range in price; with the more affordable models priced at around twenty dollars, such as the Kill A Watt P4400 by P3 International.
13. http://www.nmsea.org/Curriculum/Primer/energy_physics_primer.htm. This is a useful site for background information on energy physics
14. Work is defined as a given force applied across a distance and calculated by the formula W=f*d (where f is force measured in Newtons and d is distance measured in meters; this equation gives us work expressed in the Newton*meter, or the SI unit for energy, the Joule; where 1 J = 1 N*m).
15. Modified from the *IEA Energy Statistics Manual;* www.iea.org/stats/docs/statistics_manual.pdf
16. Tarbuck and Lutgens, *Prentice Hall Earth Science*, Ch. 4
17. Brad Pitt, Actor; see explanation from #2
18. From the International Energy Agency paper, *Worldwide Trends in Energy Use and Efficiency*, http://www.iea.org/Papers/2008/Indicators_2008.pdf
19. Energy Information Administration/International Energy Outlook 2001, based on EIA, International Energy Annual 1999,

DOE/EIA-0219(99) Washington DC, Jan. 2001 and EIA, World energy projection systel 200. http://www.grida.no/graphicslib/detail/trends-in-energy-consumption_2a09

20. From the UN 2010 Projections and US Census Bureau historical estimates; File:World-Population-1800-2100.png
21. http://ngm.nationalgeographic.com/7-billion; National Geographic presents an interactive which includes videos, interactive maps, articles, and photography that explore how the world will change in response to the current population growth