

U.S. Department of Energy

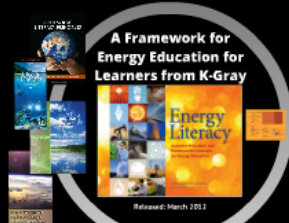
Energy Literacy Initiative

EnergyLiteracy@ee.doe.gov



#energyliteracy Webinar Agenda

- Energy Literacy Framework
- Development
- Tracking and Learning
- Intended Audience and Use
- Essential Principles
- Next Generation Science Standards and Beyond
- Energy Education Resources
- Importance of Energy Literacy
- Contact Info and Questions



Teaching and Learning

Foundational Concepts

- People are born investigators and learners.
- Effective learning focuses on a core set of ideas and practices.
- Understanding develops over time.
- Literacy requires both knowledge and practice.
- Connection to interests and experiences.
- Collaborative learning.
- Educational opportunities must be equitable and accessible to all.
- (Based on National Research Council's Framework for K-12 Science Education)

Energy Literacy Framework Intended Audience and Use

- Educators from K-Gray
- Formal and Informal
- Standards Development
- Curriculum Improvement and Design
- Assessment Development
- Educator Trainings

Essential Principles

1. Energy is a crosscutting concept.
2. Energy is a crosscutting concept.
3. Energy is a crosscutting concept.
4. Energy is a crosscutting concept.
5. Energy is a crosscutting concept.
6. Energy is a crosscutting concept.

Energy Literacy Framework and Alignment Tool

www.energyliteracyframework.org

Why does energy literacy matter?

A better understanding of energy can:

- lead to more informed decisions
- improve the security of a nation
- promote economic development
- lead to sustainable energy use
- reduce environmental risks and negative impacts
- help individuals and organizations save money

Energy Education Resources

- BITES (Buildings, Industry, Transportation, and Electricity Scenarios) Tool
- CLEAN (Climate Literacy and Energy Awareness Network)
- EIA Energy Kids and Energy Explained
- NTER (National Training and Education Resource)
- EERE Energy Education and Workforce Development

www.nextgenscience.org

K-12 Next Generation Science Standards

Energy is a crosscutting concept.

- Physical Science
- Life Science
- Earth System Science

Elementary

- Foundation
- Building
- Second Grade
- Fourth Grade
- Middle School
- Energy for life comes from the Sun
- Energy is stored in food
- Energy is used to do work

Middle School

- Kinetic energy
- Potential energy and force fields
- Thermal energy transfer
- Specific heat capacity
- Plants storing and releasing energy
- Photosynthesis
- Chemical reactions in living organisms

High School

- Energy is a crosscutting concept
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Post-Secondary

Model Energy 101 Concepts

- The energy literacy framework is a crosscutting concept
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BITES Tool

Buildings, Industry, Transportation, and Electricity Scenarios

CLEAN

Climate Literacy and Energy Awareness Network

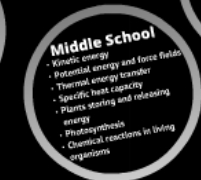
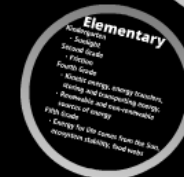
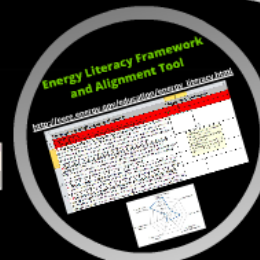
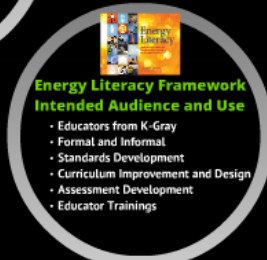
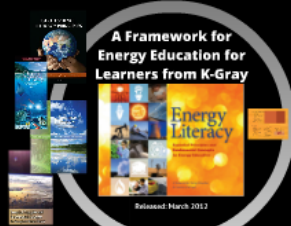
EIA

Energy Kids and Energy Explained

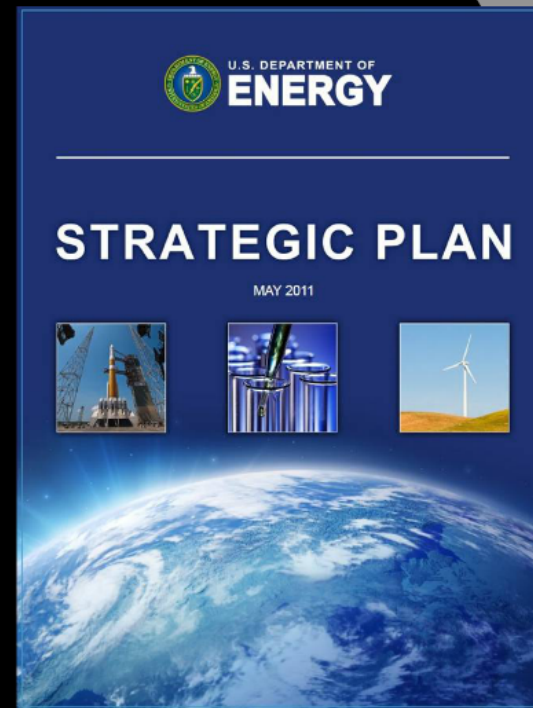
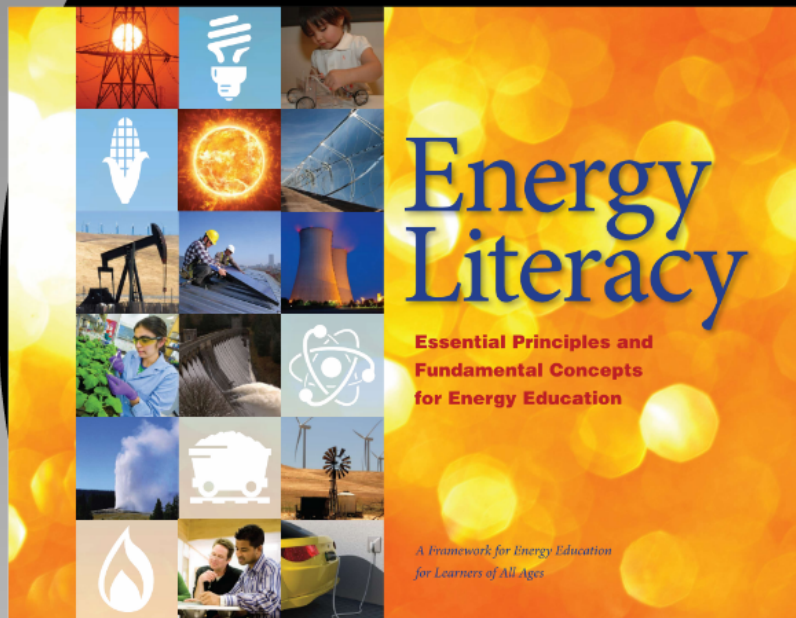
NTER

National Training and Education Resource

EnergyLiteracy@ee.doe.gov



A Framework for Energy Education for Learners from K-Gray



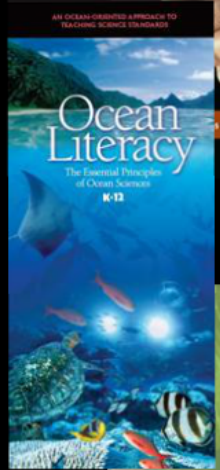


#energyliteracy

Webinar Agenda

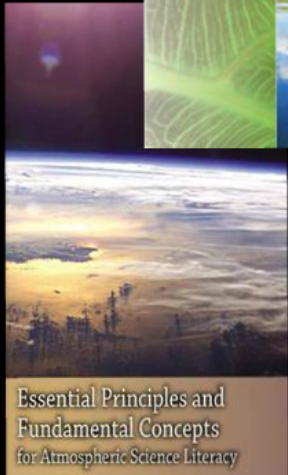
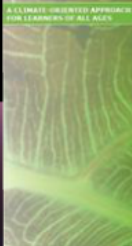
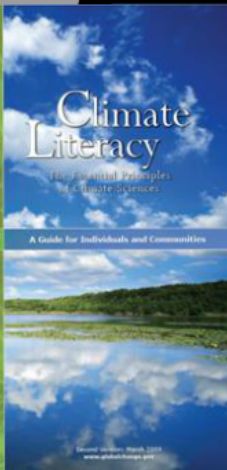
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EARTH SCIENCE LITERACY PRINCIPLES

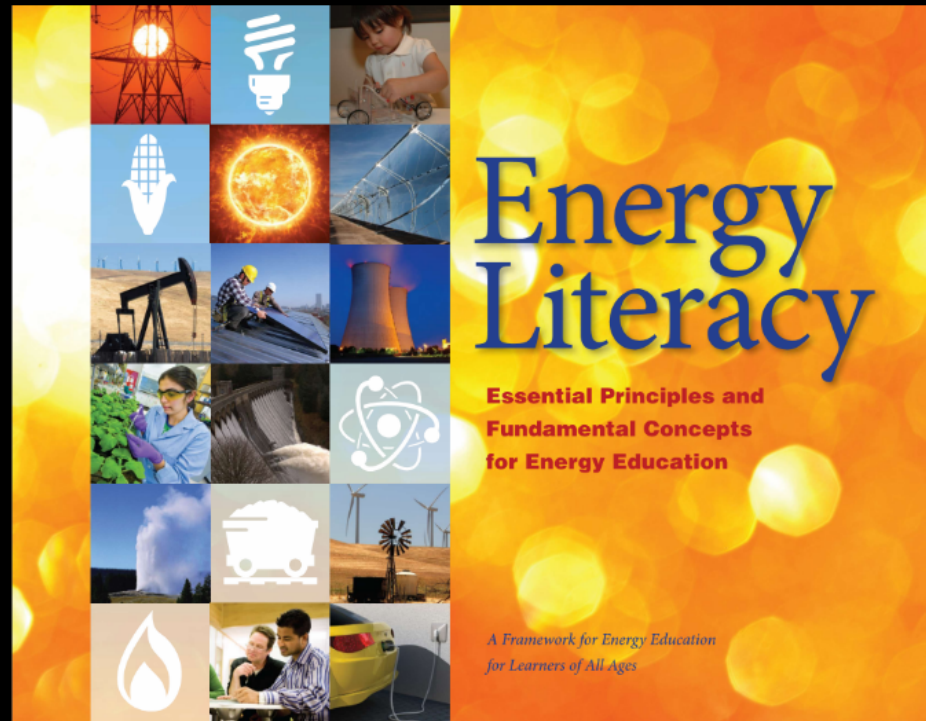


and Supporting Concepts of Earth Science

www.oceanliteracy.org



A Framework for Energy Education for Learners from K-Gray



Released: March 2012

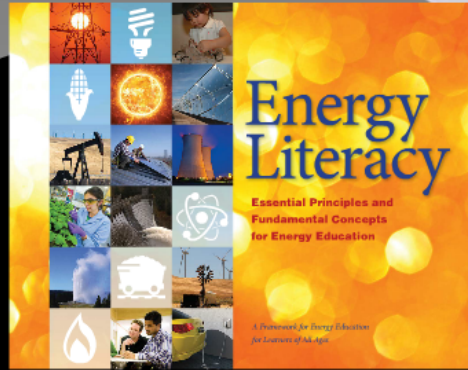
The background of the slide features a view of Earth from space, showing the blue oceans, white clouds, and brown landmasses. A large, light gray circular graphic is centered on the slide, framing the text.

Teaching and Learning

Fundamental Concepts

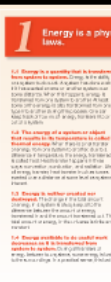
- People are born investigators and learners.
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(Based on National Research Council's Framework for K-12 Science Education)



Energy Literacy Framework Intended Audience and Use

- Educators from K-Gray
- Formal and Informal
- Standards Development
- Curriculum Improvement and Design
- Assessment Development
- Educator Trainings



1

Energy is a physical quantity that follows precise natural laws.



1.1 Energy is a quantity that is transferred from system to system.

Energy is the ability of a system to do work. A system has done work if it has exerted a force on another system over some distance. When this happens, energy is transferred from one system to another. At least some of the energy is also transformed from one type into another during this process. One can keep track of how much energy transfers into or out of a system.

1.2 The energy of a system or object that results in its temperature is called thermal energy.

When there is a net transfer of energy from one system to another, due to a difference in temperature, the energy transferred is called heat. Heat transfer happens in three ways: convection, conduction, and radiation. Like all energy transfer, heat transfer involves forces exerted over a distance at some level as systems interact.

1.3 Energy is neither created nor destroyed.

The change in the total amount of energy in a system is always equal to the difference between the amount of energy transferred in and the amount transferred out. The total amount of energy in the universe is finite and constant.

1.4 Energy available to do useful work decreases as it is transferred from system to system.

During all transfers of energy between two systems, some energy is lost to the surroundings. In a practical sense, this lost

energy has been “used up,” even though it is still around somewhere. A more efficient system will lose less energy, up to a theoretical limit.

1.5 Energy comes in different forms and can be divided into categories.

Forms of energy include light energy, elastic energy, chemical energy, and more. There are two categories that all energy falls into: kinetic and potential. Kinetic describes types of energy associated with motion. Potential describes energy possessed by an object or system due to its position relative to another object or system and forces between the two. Some forms of energy are part kinetic and part potential energy.

1.6 Chemical and nuclear reactions involve transfer and transformation of energy.

The energy associated with nuclear reactions is much larger than that associated with chemical reactions for a given amount of mass. Nuclear reactions take place at the centers of stars, in nuclear bombs, and in both fission- and fusion-based nuclear reactors. Chemical reactions are pervasive in living and non-living Earth systems.

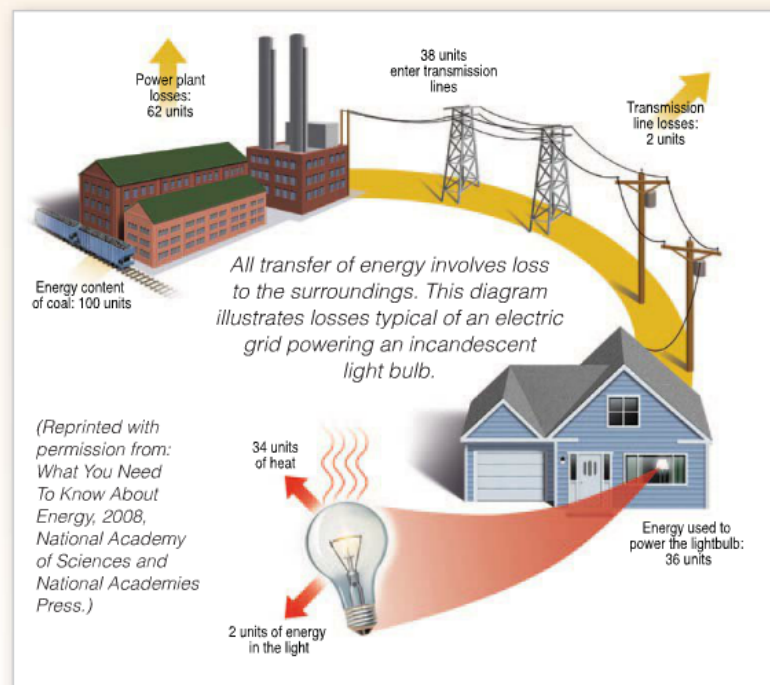
1.7 Many different units are used to quantify energy.

As with other physical quantities, many different units are associated with

energy. For example, joules, calories, ergs, kilowatt-hours, and BTUs are all units of energy. Given a quantity of energy in one set of units, one can always convert it to another (e.g., 1 calorie = 4.186 joules).

1.8 Power is a measure of energy transfer rate.

It is useful to talk about the rate at which energy is transferred from one system to another (energy per time). This rate is called power. One joule of energy transferred in one second is called a Watt (i.e., 1 joule/second = 1 Watt).



2

Physical processes on Earth are the result of energy flow through the Earth system.



2.1 Earth is constantly changing as energy flows through the system.

Geologic, fossil, and ice records provide evidence of significant changes throughout Earth's history. These changes are always associated with changes in the flow of energy through the Earth system. Both living and non-living processes have contributed to this change.

2.2 Sunlight, gravitational potential, decay of radioactive isotopes, and rotation of the Earth are the major sources of energy driving physical processes on Earth.

Sunlight is a source external to Earth, while radioactive isotopes and gravitational potential, with the exception of tidal energy, are internal. Radioactive isotopes and gravity work together to produce geothermal energy beneath Earth's surface. Earth's rotation influences global flow of air and water.



2.3 Earth's weather and climate are mostly driven by energy from the Sun. For example, unequal warming of Earth's surface and atmosphere by the Sun drives convection within the atmosphere, producing winds, and influencing ocean currents.

2.4 Water plays a major role in the storage and transfer of energy in the Earth system. The major role water plays is a result of water's prevalence, high heat capacity, and the fact that phase changes of water occur regularly on Earth. The Sun provides the energy that drives the water cycle on Earth.

2.5 Movement of matter between reservoirs is driven by Earth's internal and external sources of energy. These movements are often accompanied by a change in the physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life. Energy drives the flow of carbon between these different reservoirs.

2.6 Greenhouse gases affect energy flow through the Earth system. Greenhouse gases in the atmosphere, such as carbon dioxide and water vapor, are transparent to much of the



Storms like this hurricane are powered by the latent heat energy of water as it changes phase from liquid to gas, and then back to liquid. (Source: National Oceanic and Atmospheric Administration, Environmental Visualization Laboratory)

incoming sunlight but not to the infrared light from the warmed surface of Earth. These gases play a major role in determining average global surface temperatures. When Earth emits the same amount of energy as it absorbs, its average temperature remains stable.

2.7 The effects of changes in Earth's energy system are often not immediately apparent. Responses to changes in Earth's energy system, input versus output, are often only noticeable over the course of months, years, or even decades.

This geothermal power plant in Iceland makes use of high temperatures beneath Earth's surface to generate electricity. Nearby, people enjoy hot water heated by the same sub-surface energy sources.

3

Biological processes depend on energy flow through the Earth system.



3.1 The Sun is the major source of energy for organisms and the ecosystems of which they are a part. Producers such as plants, algae, and cyanobacteria use the energy from sunlight to make organic matter from carbon dioxide and water. This establishes the beginning of energy flow through almost all food webs.

3.2 Food is a biofuel used by organisms to acquire energy for internal living processes. Food is composed of molecules that serve as fuel and building material for all organisms as energy stored in the molecules is released and used. The breakdown of food molecules enables cells to store energy in new molecules that are used to carry out the many functions of the cell and thus the organism.

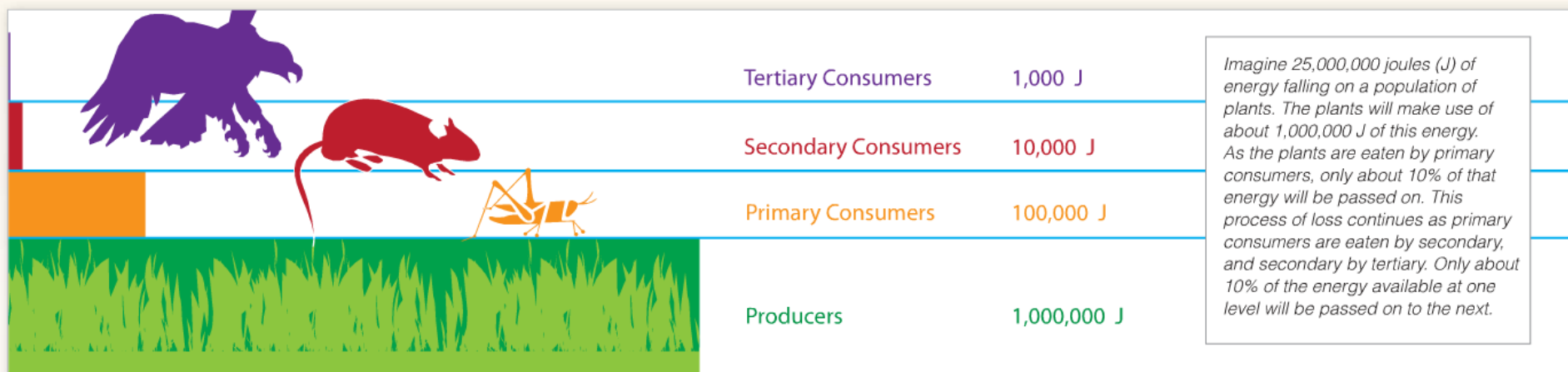
3.3 Energy available to do useful work decreases as it is transferred from organism to organism. The chemical elements that make up the molecules of living things are passed through food chains and are combined and recombined in different ways. At each level in a food chain, some energy is stored in newly made chemical structures, but most is dissipated into the environment. Continual input of energy, mostly from sunlight, keeps the process going.

3.4 Energy flows through food webs in one direction, from producers to consumers and decomposers. An organism that eats lower on a food chain is more energy efficient than one eating higher on a food chain. Eating producers is the lowest, and thus most energy efficient, level at which an animal can eat.

3.5 Ecosystems are affected by changes in the availability of energy and matter.

The amount and kind of energy and matter available constrains the distribution and abundance of organisms in an ecosystem and the ability of the ecosystem to recycle materials.

3.6 Humans are part of Earth's ecosystems and influence energy flow through these systems. Humans are modifying the energy balance of Earth's ecosystems at an increasing rate. The changes happen, for example, as a result of changes in agricultural and food processing technology, consumer habits, and human population size.



4

Various sources of energy can be used to power human activities, and often this energy must be transferred from source to destination.

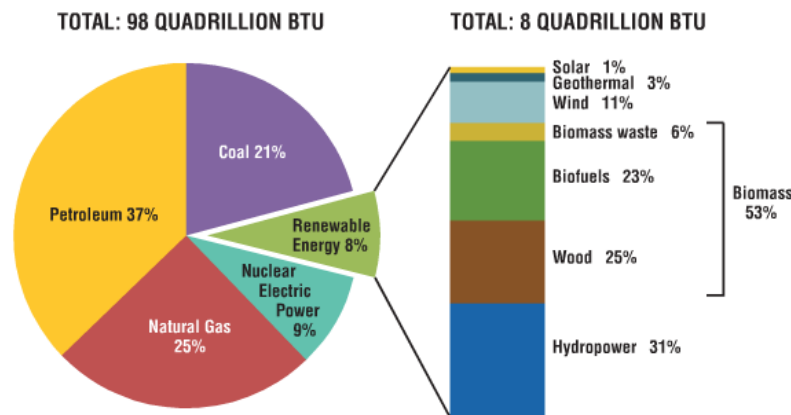


4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors. The primary sources of energy in the environment include fuels like coal, oil, natural gas, uranium, and biomass. All primary source fuels except biomass are non-renewable. Primary sources also include renewable sources such as sunlight, wind, moving water, and geothermal energy.

4.2 Human use of energy is subject to limits and constraints. Industry, transportation, urban development, agriculture, and most other human activities are closely tied to the amount and kind of energy available. The availability of energy resources is constrained by the distribution of natural resources, availability of affordable technologies, socioeconomic policies, and socioeconomic status.

4.3 Fossil and biofuels are organic matter that contain energy captured from sunlight. The energy in fossil fuels such as oil, natural gas, and coal comes from energy that producers such as plants, algae, and cyanobacteria captured from sunlight long ago. The energy in biofuels such as food, wood, and ethanol comes from energy that producers captured from sunlight very recently. Energy

U.S. Primary Energy Consumption by Energy Source, 2010



NOTE: Sum of biomass components does not equal 53% due to independent rounding.
Source: U.S. Energy Information Administration, *Annual Energy Review 2010*.

stored in these fuels is released during chemical reactions, such as combustion and respiration, which also release carbon dioxide into the atmosphere.

4.4 Humans transport energy from place to place. Fuels are often not used at their source but are transported, sometimes over long distances. Fuels are transported primarily by pipelines, trucks, ships, and trains. Electrical energy can be generated from a variety of energy resources and can be transformed into almost any other form of energy. Electric circuits are used

to distribute energy to distant locations. Electricity is not a primary source of energy, but an energy carrier.

4.5 Humans generate electricity in multiple ways. When a magnet moves or magnetic field changes relative to a coil of wire, electrons are induced to flow in the wire. Most human generation of electricity happens in this way. Electrons can also be induced to flow through direct interaction with light particles; this is the basis upon which a solar cell operates. Other means of generating electricity include electrochemical, piezoelectric, and thermoelectric.

4.6 Humans intentionally store energy for later use in a number of different ways. Examples include batteries, water reservoirs, compressed air, hydrogen, and thermal storage.

Storage of energy involves many technological, environmental, and social challenges.

4.7 Different sources of energy and the different ways energy can be transformed, transported, and stored each have different benefits and drawbacks. A given energy system, from source to sink, will have an inherent level of energy efficiency, monetary cost, and environmental risk. Each system will also have national security, access, and equity implications.

5

Energy decisions are influenced by economic, political, environmental, and social factors.



5.1 Decisions concerning the use of energy resources are made at many levels.

Humans make individual, community, national, and international energy decisions. Each of these levels of decision making has some common and some unique aspects. Decisions made beyond the individual level often involve a formally established process of decision-making.

5.2 Energy infrastructure has inertia. The decisions that governments, corporations, and individuals made in the past have created today's energy infrastructure. The large amount of money, time, and technology invested in these systems makes changing the infrastructure difficult, but not impossible. The decisions of one generation both provide and limit the range of possibilities open to the future generations.

5.3 Energy decisions can be made using a systems-based approach. As individuals and societies make energy decisions, they can consider the costs and benefits of each decision. Some costs and benefits are more obvious than others. Identifying all costs and benefits requires a careful and informed systems-based approach to decision making.

5.4 Energy decisions are influenced by economic factors. Monetary costs of energy affect energy decision making at all levels. Energy exhibits characteristics of both a commodity and a differentiable product. Energy costs are often subject to market fluctuations, and energy choices made by individuals and societies affect these

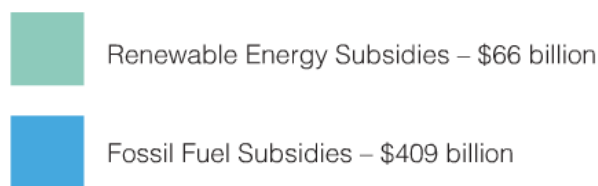
fluctuations. Cost differences also arise as a result of differences between energy sources and as a result of tax-based incentives and rebates.

5.5 Energy decisions are influenced by political factors. Political factors play a role in energy decision making at all levels. These factors include, but are not limited to, governmental structure and power balances, actions taken by politicians, and partisan-based or self-serving actions taken by individuals and groups.

5.6 Energy decisions are influenced by environmental factors. Environmental costs of energy decisions affect energy decision making at all levels. All energy decisions have environmental consequences. These consequences can be positive or negative.

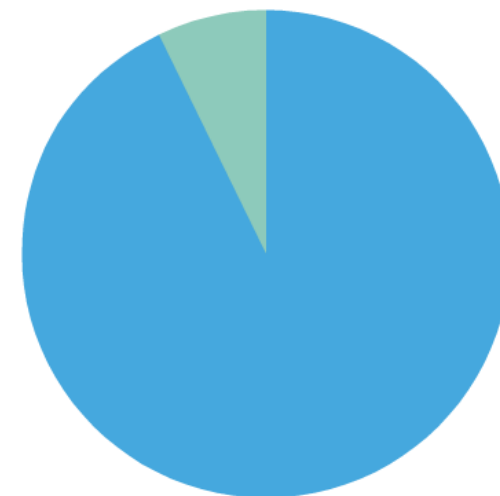
5.7 Energy decisions are influenced by social factors. Questions of ethics, morality, and social norms affect energy decision making at all levels. Social factors often involve economic, political, and environmental factors.

Global Energy Subsidies, 2010



Source – International Energy Agency (IEA), *World Energy Outlook, 2011*

Decisions regarding energy subsidies have a significant effect on energy infrastructure, energy use, and on related impacts and consequences.



6

The amount of energy used by human society depends on many factors.



6.1 Conservation of energy has two very different meanings.

There is the physical law of conservation of energy. This law says that the total amount of energy in the universe is constant. Conserving energy is also commonly used to mean the decreased use of societal energy resources. When speaking of people conserving energy, this second meaning is always intended.

6.2 One way to manage energy resources is through conservation.

Conservation includes reducing wasteful energy use, using energy for a given purpose more

efficiently, making strategic choices as to sources of energy, and reducing energy use altogether.

6.3 Human demand for energy is increasing.

Population growth, industrialization, and socioeconomic development result in increased demand for energy. Societies have choices with regard to how they respond to this increase. Each of these choices has consequences.

6.4 Earth has limited energy resources.

Increasing human energy consumption places stress on the natural processes that renew some energy resources and it depletes those that cannot be renewed.

conserve energy. These actions might come in the form of changes in behavior or in changes to the design of technology and infrastructure. Some of these actions have more impact than others.

6.7 Products and services carry with them embedded energy.

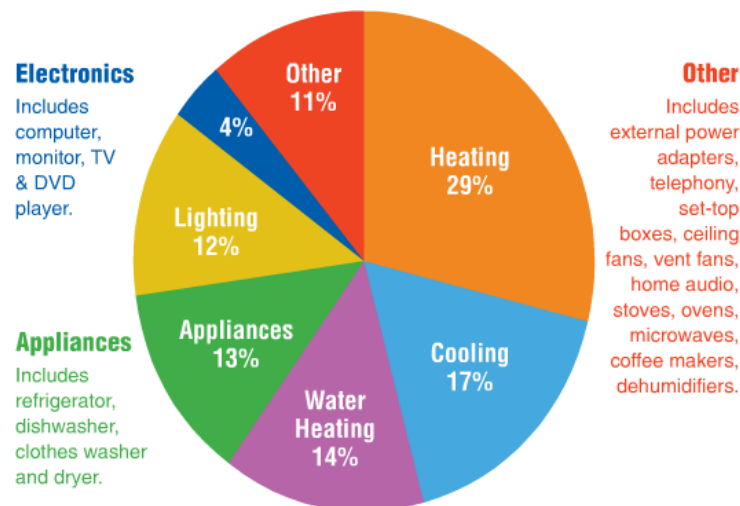
The energy needed for the entire lifecycle of a product or service is called the “embedded” or “embodied” energy. An accounting of the embedded energy in a product or service, along with knowledge of the source(s) of the energy, is essential when calculating the amount of energy used and in assessing impacts and consequences.

6.8 Amount of energy used can be calculated and monitored.

An individual, organization, or government can monitor, measure, and control energy use in many ways. Understanding utility costs, knowing where consumer goods and food come from, and understanding energy efficiency as it relates to home, work, and transportation are essential to this process.

Where Does My Money Go?

Annual Energy Bill for a typical U.S. Single Family Home is approximately \$2,200.



Source: Typical House memo,

Lawrence Berkeley National Laboratory, 2009 and Typical house_2009_Reference.xls spreadsheet.

Average price of electricity is 11.3 cents per kilo-watt hour. Average price of natural gas is \$13.29 per million Btu.

6.5 Social and technological innovation affects the amount of energy used by human society.

The amount of energy society uses per capita or in total can be decreased. Decreases can happen as a result of technological or social innovation and change. Decreased use of energy does not necessarily equate to decreased quality of life. In many cases it will be associated with increased economic and national security, reduced environmental risks, and monetary savings.

6.6 Behavior and design affect the amount of energy used by human society.

There are actions individuals and society can take to

The Energy Star program is run jointly by the U.S. Department of Energy and the Environmental Protection Agency. The Energy Star logo designates products as highly energy efficient.



7

The quality of life of individuals and societies is affected by energy choices.



7.1 Economic security is impacted by energy choices. Individuals and society continually make energy choices that have economic consequences. These consequences come in the form of monetary cost in general and in the form of price fluctuation and instability specifically.

7.2 National security is impacted by energy choices. The security of a nation is dependent, in part, on the sources of that nation's energy supplies. For example, a nation that has diverse sources of energy that come mostly from within its borders is more secure than a nation largely dependent on foreign energy supplies.

7.3 Environmental quality is impacted by energy choices. Energy choices made by humans have environmental consequences. The quality of life of humans and other organisms on Earth can be significantly affected by these consequences.

7.4 Increasing demand for and limited supplies of fossil fuels affects quality of life. Fossil fuels provide the vast majority of the world's energy. Fossil fuel supplies are limited. If society has not transitioned to sources of energy that are renewable before depleting Earth's fossil fuel supplies, it will find itself in a situation where energy demand far exceeds energy supply. This situation will have many social and economic consequences.

7.5 Access to energy resources affects quality of life. Access to energy resources, or lack thereof, affects human health, access to education, socioeconomic status, gender equality, global partnerships, and the environment.

7.6 Some populations are more vulnerable to impacts of energy choices than others. Energy decisions have economic, social, and environmental consequences. Poor, marginalized, or underdeveloped populations can most benefit from positive consequences and are the most susceptible to negative consequences.

At left - Students from a school in Madavunu, Ghana ride a merry-go-round that generates electricity for the school. The school and village are otherwise without electricity.

At right - Students do school work by the light of a rechargeable LED lamp. The battery-powered lamps are recharged by the merry-go-round and can be used in classrooms and at home.

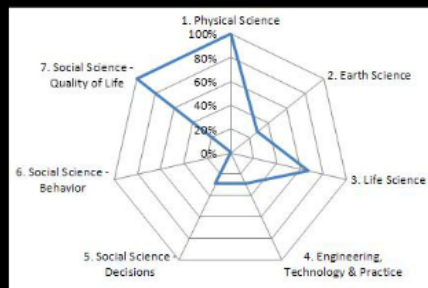
(Photos courtesy of Empower Playgrounds. Chris Owen, photographer.)



Energy Literacy Framework and Alignment Tool

http://eere.energy.gov/education/energy_literacy.html

	A	B	C
1	Essential Principle/Fundamental Concept	Alignment	Comments
2	Physical Science	8	
3	1. Energy is a physical quantity that follows precise natural laws.	0	
4	1.1 Energy is a quantity that is transferred from system to system. Energy is the ability of a system to do work. A system has done work if it has exerted a force on another system over some distance. When this happens energy is transferred from one system to another. At least some of the energy is also transformed from one type into another during this process. One can keep track of how much energy transfers into or out of a system.		
5	1.2 The energy of a system or object that results in its temperature is called thermal energy. When there is a net transfer of energy from one system to another, due to a difference in temperature, we call the energy transferred heat. Heat transfer happens in three ways: convection, conduction and radiation. Like all energy transfer, heat transfer involves forces exerted over a distance at some level as systems interact.		Indicate if your curriculum, program or activity thoroughly ADDRESSES the Energy Literacy Fundamental Concept, if it SUPPORTS the concept, or if it is NOT ADDRESSED.
6	1.3 Energy is neither created nor destroyed. The change in the total amount of energy in a system is always equal to the difference between the amount of energy transferred in and the amount transferred out. The total amount of energy in the universe is finite and constant.		
7	1.4 Energy available to do useful work decreases as it is transferred from system to system. During all transfers of energy between two systems, some energy is lost to the surroundings. In a practical sense, this lost energy has been "used up," even though it is still around somewhere. A more efficient system will lose less energy, up to a theoretical limit.		





www.nextgenscience.org

K-12

Next Generation Science Standards

Energy is a crosscutting concept.

- Physical Science
- Life Science
- Earth System Science

Post-Seco

High S
• Conserv
• Ener



Elementary

Kindergarten

- **Sunlight**

Second Grade

- **Friction**

Fourth Grade

- **Kinetic energy, energy transfers, storing and transporting energy,**
- **Renewable and non-renewable sources of energy**

Fifth Grade

- **Energy for life comes from the Sun, ecosystem stability, food webs**

Middle School

- **Kinetic energy**
- **Potential energy and force fields**
- **Thermal energy transfer**
- **Specific heat capacity**
- **Plants storing and releasing energy**
- **Photosynthesis**
- **Chemical reactions in living organisms**

High School

- **Conservation of energy**
- **Energy transfer**
- **Forms of energy and force fields**
- **Human energy use and technology**
- **Nuclear processes**
- **Photosynthesis**
- **Chemical processes for living organisms**
- **Energy flow in ecosystems**
- **Carbon cycle**
- **Environmental issues and solutions**
- **Sustainability**
- **Human impacts**

Post-Secondary Model Energy 101 Courses

http://eere.energy.gov/education/energy_101.html

- Interdisciplinary Higher Education Course
- Teaching the Fundamentals of Energy
- A pilot course launched at the
University of Maryland - College Park

E-mail Questions and Comments:

[**Energy101@ee.doe.gov**](mailto:Energy101@ee.doe.gov)



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EERE
and Work
<http://eere>

- K-12 Les
- Scholars
- Student C
- Green You
- Career Info
- Energy Lite
- Energy 101

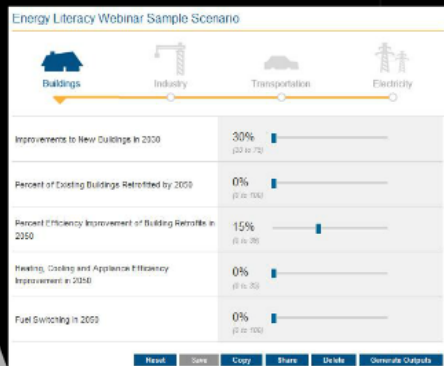
National
WV
open sourc
<http://eere.energy>



BITES Tool

Buildings, Industry, Transportation and Electricity
Scenarios Tool

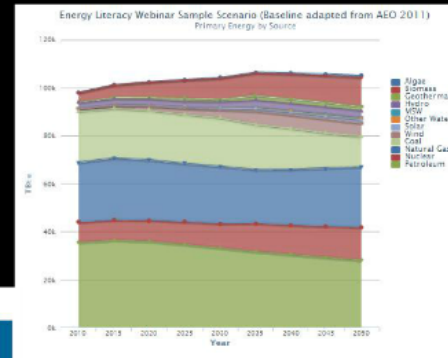
<https://bites.nrel.gov/>



Energy Literacy Webinar Sample Scenario (Baseline adapted from AEO 2011)



Name:	Energy Literacy Webinar Sample Scenario
Description:	[New Scenario Description]
Input Mode:	Basic
Base Case:	Baseline adapted from AEO 2011
Author:	dan@nrel.gov
Created:	1/1/11
Last Update:	1/1/11



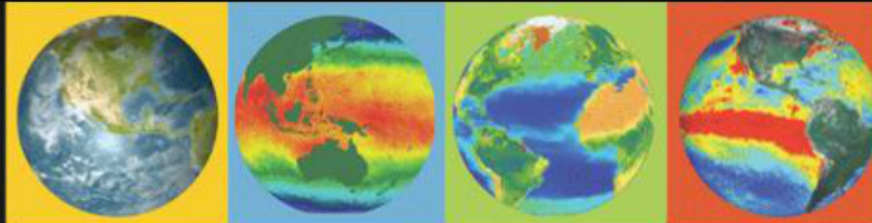
Feedback: bites@nrel.gov

CLEAN

Climate Literacy and Energy Awareness Network

<http://cleanet.org>

CLEAN



CLIMATE LITERACY & ENERGY AWARENESS NETWORK

- Collection of reviewed educational resources
 - K-Gray with emphasis on K-12
 - Aligned with Climate and Energy Literacy

Climate (and Energy) Literacy Network Contact

Tamara Ledley: tamara_ledley@terc.edu

EIA

Energy Information Administration



<http://eia.gov/kids/>



<http://eia.gov/energyexplained/>

State Energy Profiles

<http://eia.gov/beta/state/>

NTER

National Training and Education Resource

www.nterlearning.org

open source, web-based learning platform

http://eere.energy.gov/education/webcast_nter.html



EERE Energy Education and Workforce Development

<http://eere.energy.gov/education/>

- K-12 Lesson Plans and Activities
- Scholarship, Internship, Fellowship Info
- Student Competitions
- Green Your School
- Career Information and Links
- Energy Literacy
- Energy 101

The background of the slide is a high-contrast image of Earth as seen from space, showing the curvature of the planet, blue oceans, and brown/green landmasses. A large, semi-transparent grey circle is centered on the slide, framing the text.

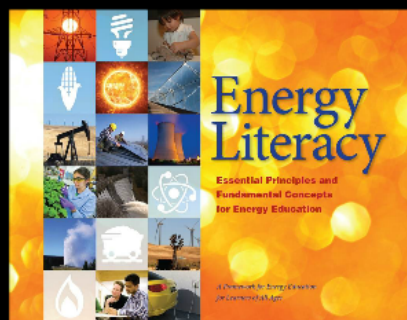
Why does energy literacy matter?

A better understanding of energy can:

- **lead to more informed decisions**
- **improve the security of a nation**
- **promote economic development**
- **lead to sustainable energy use**
- **reduce environmental risks and negative impacts**
- **help individuals and organizations save money**

Contact Info

Energy Literacy Initiative



<http://eere.energy.gov/education/>

E-mail Questions and Comments:
EnergyLiteracy@ee.doe.gov

#energyliteracy