

## **SOLAR SITE ANALYSIS: THE PVWATTS CALCULATOR**

### **MAY ADVANCE THESE NATIONAL ENERGY LITERACY STANDARDS:**

#### **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.

**1.5 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.

**1.7 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.**

**2.2 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.

#### **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.

**4.5 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.

**4.7 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.**

**5.3 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.

**5.6 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.

**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.

**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 quality of life in the form of 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 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.

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

**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.