

# **Tennessee Science Standards 2011-2012 Implementation**

## **Energy Systems**

### **Embedded Technology and Engineering**

#### **Conceptual Strand**

*Society benefits when engineers apply scientific discoveries to design materials and processes that develop into enabling technologies.*

#### **Guiding Question**

*How do science concepts, engineering skills, and applications of technology improve the quality of life?*

#### **Course Level Expectation:**

- T/E.1 Explore the impact of technology on social, political, and economic systems.
- T/E.2 Differentiate among elements of the engineering design cycle: design constraints, model building, testing, evaluating, modifying, and retesting.
- T/E.3 Explain the relationship between the properties of a material and the use of the material in the application of a technology.
- T/E.4 Describe the dynamic interplay among science, technology, and engineering within living, earth-space, and physical systems.

#### **Checks for Understanding**

- T/E.1 Select appropriate tools and procedures best suited to conduct a specified scientific inquiry.
- T/E.2 Apply the engineering design process to construct a prototype that meets developmentally appropriate specifications.
- T/E.3 Evaluate a protocol to determine the degree to which an engineering design process was successfully applied.
- T/E.4 Explore how the unintended consequences of new technologies can impact human and non-human communities.
- T/E.5 Evaluate the overall benefit to cost ratio of a new technology.
- T/E.6 Present research on current engineering technologies that contribute to improvements in our daily lives.
- T/E.7 Design a series of multi-view drawings that can be used by others to construct an adaptive design and test its effectiveness.

# Standard 1 - Electricity and Magnetism

## Conceptual Strand 1

*Electric charge is the fundamental quantity that underlies electricity and magnetism.*

## Guiding Question 1

*How does an electric charge produce electric and magnetic fields?*

## Course Level Expectation:

- 1.1 Examine the properties of electric forces, electric charges, and electric fields.
- 1.2 Explore the flow of charge and electric currents.
- 1.3 Investigate Ohm's law.
- 1.4 Compare and contrast series and parallel circuits.
- 1.5 Analyze schematic diagrams.
- 1.6 Understand magnetic poles, magnetic fields, and investigate electromagnetic induction.
- 1.7 Understand that moving charges give rise to magnetism.

## Checks for Understanding

- 1.1 Create a simple electromagnet.
- 1.2 Draw an electric field, given a scenario of charged particles.
- 1.3 Solve problems of resistance using Ohm's law  
[ $E = IR$  (or  $V=IR$ )].
- 1.4 Draw and explain series and parallel circuits.
- 1.5 Solve problems related to voltage, current, and resistance  
Voltage,  $V = IR$ ;  
Series circuits,  $R_T = R_1 + R_2 + \dots$ ,  
 $I_T = I_1 = I_2 = \dots$ ,  $V_T = V_1 + V_2 + \dots$ ;  
Parallel circuits,  $1/R_T = 1/R_1 + 1/R_2 + \dots$ ,  
 $I_T = I_1 + I_2 + \dots$ ,  $V_T = V_1 = V_2 = \dots$
- 1.6 Build series and parallel circuits to demonstrate how they function.
- 1.7 Demonstrate a generated current by electromagnetic induction.
- 1.8 Design a lab to demonstrate the flow of charged particles and an electric current.
- 1.9 Analyze a given group of charges for repulsion and attraction.
- 1.10 Distinguish between charged particles related to repulsion and attraction.
- 1.11 Describe the electric field that fills the space around a charged particle or group of charges  
Coulomb's law,  $F = k (Q_1 Q_2) / d^2$ .

- 1.12 Identify components of series and parallel circuits and solve problems related to voltage, current, and resistance.
- 1.13 Describe how current is generated by electromagnetic induction.

## **Standard 2 - Nuclear Physics**

### **Conceptual Strand 2**

*Nuclear physics can be better understood with a deeper understanding of particle physics.*

### **Guiding Question 2**

*How is the investigation of nuclear particles related to a better understanding of nuclear physics?*

### **Course Level Expectation:**

- 2.1 Investigate the properties and structure of the atom.
- 2.2 Explore the dynamics of the nucleus: radioactivity, radiocarbon/uranium dating, and half-life.
- 2.3 Compare and contrast nuclear fission and nuclear fusion.

### **Checks for Understanding**

- 2.1 Write and balance equations for the three forms of radioactive decay.
- 2.2 Solve half-life problems  
Decay constant:  $k=0.693/T_{(1/2)}$ ;  
Nuclear decay:  $A_f=A_0e^{kt}$ .
- 2.3 Explain dating methods using carbon-14 or uranium.
- 2.4 Investigate the concept of half-life.
- 2.5 Investigate the history and current events associated with nuclear and radioactive science.
- 2.6 Identify parts of an atom (protons, electrons, neutrons, nucleus, and electron cloud).
- 2.7 Describe the properties and location of subatomic particles.
- 2.8 Describe and identify the three basic forms of radioactivity (alpha particles, beta particles, and gamma rays)
- 2.9 Distinguish between nuclear fission and nuclear fusion.
- 2.10 Explain the changes in atomic number or mass number for each form of radioactivity.
- 2.11 Discuss transmutation and trans uranium.

# Standard 3 – Power Generation - Conventional

## Conceptual Strand 3

*Power has a major impact on our lifestyle and environment*

## Guiding Question 3

*What are the primary energy resources of electric power generation?*

## Course Level Expectation

- 3.1 Identify the energy resources of conventional electric power generation systems (coal, gas, hydroelectric, and nuclear).
- 3.2 Identify various conventional electric power generation fuel sources and the cost/ efficiency/ environmental issues associated with each:

## Checks for Understanding

- 3.1 Explain the conventional electric power generation systems and process (coal, gas, hydroelectric, and nuclear).
- 3.2 Identify electric power generation equipment and systems.
- 3.3 Explain how oil is produced and list its advantages and disadvantages
- 3.4 Explain how coal is produced and what are its advantages and disadvantages
- 3.5 Explain how natural gas is produced and what are its advantages and disadvantages
- 3.6 Define potential energy
- 3.7 Explain how water is used in hydroelectric power generation and what are its advantages and disadvantages.
- 3.8 Explain how uranium is produced and what are its advantages and disadvantages

# Standard 4 – Power Grid – Smart Transmission and Distribution

## Conceptual Strand 4

*Power is distributed from the generator to businesses and homes*

## Guiding Question 4

*What are the characteristics of the power transmission and distribution?*

## Course Level Expectation

- 4.1 Understand how electric power is transmitted from the producer to the distributor.
- 4.2 Understand the impact of Smart Grid technologies on the transmission process.
- 4.3 Understand the electric power distribution system to industrial and residential customers
- 4.4 Understand emerging technologies in the electric power distribution system and their potential impact on consumers

## Checks for Understanding

- 4.1 Explain the electric power transmission process
- 4.2 Discuss the application of different electric power transmission principles (including AC vs. DC).
- 4.3 Name electric power transmission equipment and systems.
- 4.4 Discuss the Smart Grid technologies and how they will affect the reliability of the system
- 4.5 Explain the power distribution process
- 4.6 Discuss the need for electrical distribution systems and how they are designed to operate
- 4.7 Name the electric power distribution system equipment and what the various components do

- 4.8 Discuss the emerging technologies in electric power distribution, including distribution automation, distributed generation, and Smart Grid systems, including the impact of Smart Grid systems on residential customers

## **Standard 5 – Power Generation - Renewable**

### **Conceptual Strand 5**

*Electric power can be generated from renewable energy resources.*

### **Guiding Question 5**

*What are the benefits and dis-benefits of alternative energy resources?*

### **Course Level Expectation**

- 5.1 Understand the potential of solar energy
- 5.2 Understand the potential for wind energy
- 5.3 Understand the potential for biomass and biofuels
- 5.4 Understand the potential for hydro power generation

### **Checks for Understanding**

- 5.1 Describe solar energy and how it is harnessed.
- 5.2 Explain the significance and historical foundations of solar energy and its pioneers (Horace de Saussure and Clarence Kemp).
- 5.3 Explain the difference between passive solar and active solar.
- 5.4 Draw and label a diagram of PV cells (e.g. array, panel, module, boron-enriched silicon).
- 5.5 Describe a central receiver system.
- 5.6 Draw and label a diagram of a solar thermal plant.
- 5.7 Evaluate the advantages and disadvantages of using solar energy.
- 5.8 Describe wind energy and the way it is harnessed.
- 5.9 Explain the significance of wind energy and its pioneers (Charles Brush).
- 5.10 Define kinetic energy.
- 5.11 List and describe the topography and weather patterns of the states that are considered the “Saudi Arabia of wind power.”
- 5.12 Explain the acronym NIMBY (Not In My Backyard).
- 5.13 Explain why farmers and ranchers are amenable to wind technology.
- 5.14 Evaluate the advantages and disadvantages to wind technology.
- 5.15 Discuss the major sources of biomass.
- 5.16 Define biofuels (e. g. ethanol, biodiesel, and methanol).
- 5.17 Outline the pyramid energy flow including the different trophic levels.
- 5.18 Describe the major sources, scale, and impacts of biomass energy.
- 5.19 Draw and label a diagram of biomass plantations.
- 5.20 List the advantages and disadvantages of using biomass for energy (e.g. CO<sub>2</sub> emissions, photosynthetic efficiency, cost, etc.).

## **Standard 6 - Energy Resources and Consumption**

## **Conceptual Strand 6**

*Humans use both renewable and nonrenewable sources of energy resources.*

### **Guiding Question 6**

*What are the environmental consequences of energy resource use?*

### **Course Level Expectations:**

- 6.1 Compare and contrast various energy resources.
- 6.2 Compare sustainable and non-sustainable resources
- 6.3 Analyze the past and present use of energy resources.
- 6.3 Predict future trends in energy resource use.
- 6.4 Understand the critical need of energy conservation

### **Checks for Understanding**

- 6.1 Construct visual displays to illustrate the source, uses, advantages, disadvantages, availability, and cost of energy resources (i.e. coal, petroleum, nuclear, solar, hydro, wind, geothermal, biofuels, Hydrogen, tidal).
- 6.2 Understand World's and US's energy needs
- 6.3 Provide examples of sustainable and non-sustainable resources
- 6.4 Explain the concept of full cost pricing as it relates to electricity production.
- 6.5 Summarize renewable and nonrenewable energy resource use and consumption through time.
- 6.6 Compare the electric power consumption of common appliances/electronic devices and calculate the life cycle cost.
- 6.7 Describe energy saving alternatives to common appliances and electronic devices and explore energy saving alternatives.
- 6.7 Calculate personal carbon footprint and formulate plans for personal and commercial energy conservation.
- 6.8 Research technological advances in energy resources.
- 6.9 Research technological advances in energy conservation.