Fundamentals of Power Generation

FP8411 36 weeks

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Office of Career, Technical, and Adult Education

Course Description

Suggested Grade Level: 9 or 10

This course provides students with a foundation in electricity and power generation methods. Students participate in hands-on activities such as designing and building models of power generation systems and components. Students explore policies, trends, innovation, and careers in energy.

Task Essentials Table

- Tasks/competencies designated by plus icons (⊕) in the left-hand column(s) are essential
- Tasks/competencies designated by empty-circle icons (○) are optional
- Tasks/competencies designated by minus icons (⊖) are omitted
- Tasks marked with an asterisk (*) are sensitive.

Task Number	FP8411	Tasks/Competencies
Describing Energy Types and Transformations		
39	⊕	Describe forms of energy and their uses.
40	⊕	Define *energy*.
41	⊕	Identify units of measure.
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43	⊕	Explain energy conversion.
Exploring Sources of Energy		
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45	⊕	Evaluate energy sources that are nonrenewable, renewable, and inexhaustible.
46	⊕	Diagram the life cycle of energy sources.
47	⊕	Analyze byproduct management associated with the use of each.
48	⊕	Compare the footprint of various energy sources.

Describing Electrical Theory			
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50	⊕	Describe electric current.	
51	⊕	Explain the difference between conductive and nonconductive material.	
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53	⊕	Describe electric resistance.	
54	⊕	Explain Ohm's law.	
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57	⊕	Construct circuits that contain resistors.	
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Exploring Turbines			
59	⊕	Exploring Turbines.	
60	⊕	Diagram the major components of a gas turbine and explain its purpose.	
61	⊕	Diagram the major components of a steam turbine and explain its purpose.	
62	⊕	Diagram the major components of a water turbine and explain its purpose.	
63	⊕	Diagram the major components of a wind turbine and explain its purpose.	
64	⊕	Compare the characteristics of different types of turbines.	
65	⊕	Design a turbine model.	
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66	⊕	Explain Faraday's law of induction.	

67	⊕	Describe the fundamental operating principal of a generator.	
68	⊕	Diagram the major components of a generator.	
69	⊕	Explain the difference between a generator and an alternator.	
70	⊕	Describe the electrical output of a simple generator and how the power produced can be conditioned.	
Exploring Photovoltaics			
71	⊕	Define *photovoltaics* (PV).	
72	⊕	Investigate the workings of a solar panel.	
73	⊕	Compare PV and traditional power sources.	
74	⊕	Describe effects on solar performance.	
75	⊕	Design a solar-powered model.	
Exploring Environmental Effects in Energy and Power			
76	⊕	Explore the effect of greenhouse gas emissions from energy production on the environment.	
77	⊕	Investigate the environmental effects of all energy sources.	
78	⊕	Research mitigation techniques for reducing environmental effects from energy sources.	
Exploring Health and Safety Challenges in Energy and Power			
79	⊕	Describe health challenges (past, present, and future) posed by and to the energy industry.	
80	⊕	Describe safety challenges (past, present, and future) posed by and to the energy industry.	
81	⊕	Explain the role of regulatory agencies on health and safety.	
82	⊕	Follow safety guidelines.	
83	⊕	Present on health and safety solutions within the industry.	
Describing Energy Policy and Trends			

84	⊕	Define *energy policy*.	
85	⊕	Identify environmental, health, and safety aspects of the energy life cycle.	
86	⊕	Discuss examples of energy efficiency policy and why they are important.	
87	⊕	Discuss examples of renewable energy and storage policy and why they are important.	
88	⊕	Discuss examples of energy policy and why they are important.	
89	⊕	Discuss examples of research and development energy policy and why they are important.	
90	⊕	Discuss examples of other kinds of energy policy and why they are important.	
91	⊕	Analyze challenges that have led to developing new energy policies.	
92	⊕	Identify decommissioning and reclamation efforts.	
93	⊕	Research energy policy trends.	
94	⊕	Investigate career options within the energy sector.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

Describing Energy Types and Transformations

Task Number 39

Describe forms of energy and their uses.

Definition

Description should include

- thermal – internal energy of a system in thermodynamic equilibrium by virtue of its temperature, used for such things as home heating, transportation, cooking, water heating, industrial production, boilers, nuclear medicine, and x-rays
- mechanical – energy associated with the motion and position of an object, used for such things as transportation, power production, wind turbines, and steam turbines
- chemical – energy derived from chemical reactions (e.g., batteries, fuel, food), used for such things as transportation and electronics
- electrical – energy made available by the flow of electric charge through a conductor for residential, commercial, and industrial use
- radiant – energy transferred by electromagnetic radiation (e.g., light)
- nuclear – energy stored in the nuclei of atoms
- sound – produced by vibrations, when energy travels through a substance in the form of waves
- elastic – potential energy stored in a coiled spring
- gravitational – potential energy stored in objects higher than ground level or below.

Process/Skill Questions

- Under which type of energy does solar photovoltaic (PV) energy fall?
- What is *hybrid energy*?
- What type of energy does a battery operate on? Why is that the best choice?
- What types of energy are used in the transportation industry?

ITEEA National Standards

1. The Characteristics and Scope of Technology

16. Energy and Power Technologies

2. The Core Concepts of Technology

Task Number 40

Define *energy*.

Definition

Definition should include

- energy as the ability to produce change or do work
- the difference between kinetic and potential energy
- the difference between energy and power
    - energy – the capacity to do work
    - power – the rate at which work is done
- energy is derived from the use of such forms as thermal, mechanical, or chemical resources.

Process/Skill Questions

- What are examples of kinetic and potential energy?
- What is the difference between power and energy? What are examples of each?
- What are examples of energy doing work? How is the rate of power measured?

ITEEA National Standards

1. The Characteristics and Scope of Technology

16. Energy and Power Technologies

2. The Core Concepts of Technology

Task Number 41

Identify units of measure.

Definition

Identification should include

- amps
- watts
- volts
- ohms
- Roentgen equivalent man (REM)
- gallons per minute (GPM)
- rad
- British thermal units (BTUs)
- calories
- horsepower
- pounds per square inch (PSI)
- torque
- Fahrenheit (lbs/hr).

Process/Skill Questions

- How does one read the amperage of a motor?
- What type of meter does one use to read voltage?
- How is a home blood-pressure monitor kit similar to some of these tools?
- What is the purpose of the spring scale?

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16. Energy and Power Technologies

Task Number 42

Demonstrate energy transformation.

Definition

Demonstration should include

- the relationship between the source and the final output
- energy transfer and storage
- energy efficiency
    - loss of energy in the transformation process (i.e., put in 100 percent, never get 100 percent out).

Teacher resource:
- The National Energy Education Development (NEED) Project

Process/Skill Questions

- How is energy transferred?
- Why is energy never 100 percent efficient?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Task Number 43

Explain energy conversion.

Definition

Explanation should include the relationship between the source and the final output and the concepts of

- efficiency—loss of energy in the conversion process (put in 100 percent, never get 100 percent out)
- kinetic vs. potential energy
- Rankine Cycle
- Mollier Diagram
- heat rate.

Process/Skill Questions

- What are common applications of chemical energy?
- How might one determine the type of energy to be used?
- How is electricity a result of thermal, mechanical, or chemical generation?
- What types of energy are used in the transportation industry?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Exploring Sources of Energy

Task Number 44

Identify sources of energy.

Definition

Identification may include

- fossil fuels (i.e., coal, and oil)
- gas
    - natural gas
    - renewable natural gas
    - hydrogen
    - propane
- solar (i.e., thermal, PV, and concentrating)
- nuclear (i.e., fission, fusion)
- hydroelectric (e.g., impoundment, run-of-river)
- wind (i.e., onshore and offshore)
- ocean energy (i.e., wave, tidal/current, and ocean thermal energy conversion [OTEC])
- geothermal
- biomass (e.g., algae, hemp, crop and forestry debris)
- waste-to-energy
- light fuel oil
- diesel.

Process/Skill Questions

- What energy sources are used in Virginia?
- What is the energy profile for Virginia?

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16. Energy and Power Technologies

2. The Core Concepts of Technology

Task Number 45

Evaluate energy sources that are nonrenewable, renewable, and inexhaustible.

Definition

Evaluation should include

- definitions of *nonrenewable, renewable*, and *inexhaustible energy sources*
- examples of energy sources categorized as nonrenewable, renewable, and inexhaustible

- uses for nonrenewable, renewable, and inexhaustible energy sources in specific geographic locations
- positive and negative effects of nonrenewable, renewable, and inexhaustible energy sources on the global environment, society, and the individual.

Process/Skill Questions

- What is the difference between a renewable and inexhaustible energy source?
- What is an example of a nonrenewable, renewable, and an inexhaustible energy source?
- Where do these energy sources thrive geographically?

ITEEA National Standards

16. Energy and Power Technologies

2. The Core Concepts of Technology

5. The Effects of Technology on the Environment

Task Number 46

Diagram the life cycle of energy sources.

Definition

Diagram should include

- traditional
    - extraction
    - refinement
    - distribution
    - generation
    - usage
    - decommissioning/reclamation
- non-traditional
    - generation
    - usage decommissioning/reclamation.

Process/Skill Questions

- Where is mining used primarily for extraction?
- What types of equipment, tools, and machinery are used in extraction?
- What safety measures need to be taken during extraction of energy sources?

- How are oil and gas extracted?

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Task Number 47

Analyze byproduct management associated with the use of each.

Definition

Analysis should include methods and issues related to the management of byproducts from

- thermal energy, such as
    - filtration
    - chemical treatment
    - cooling tanks
    - ventilation
- mechanical energy, such as
    - recycling
    - cooling
    - maintenance
    - replacement of parts
- chemical energy, such as
    - hazardous materials (HazMat)
    - disposal
    - containment
- recycling and reclamation.

Process/Skill Questions

- What is management of byproducts of various energy forms?
- What is an example of managing byproducts of chemical energy?

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Task Number 48

Compare the footprint of various energy sources.

Definition

Comparison should include

- physical footprint (acreage)
- carbon footprint
- capacity (as part of the grid)
- market share
- energy sources from specific geographic locations (e.g., physical location, infrastructure, population densities, environmental concerns).

Comparison should utilize maps. U.S. Energy Information Administration

Process/Skill Questions

- What does the term *footprint* mean?
- How can market share have a footprint?

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Describing Electrical Theory

Task Number 49

Explain electric charge.

Definition

Explanation should include

- molecules

- atoms
- electrons
- protons
- neutrons
- negative charge
- positive charge.

Process/Skill Questions

- What are molecules?
- What are the parts of an atom?
- How does an atom become negatively charged?

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16. Energy and Power Technologies

Task Number 50

Describe electric current.

Definition

Description should include the notion that electrons, which have a negative charge, will move when exposed to a potential and given a conductive pathway. That movement is called current, and it is measured in amperes (amps).

Process/Skill Questions

- What does *amp* mean?
- What do electrons have to do with electric current?

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16. Energy and Power Technologies

2. The Core Concepts of Technology

Task Number 51

Explain the difference between conductive and nonconductive material.

Definition

Explanation should include

- conductive materials (e.g., metals) contain free electrons that promote current to flow when voltage is applied
- non-conductive materials (e.g., glass, plastic) do not.

Process/Skill Questions

- What materials conduct electricity?
- What is another name for non-conductive material?

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12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

2. The Core Concepts of Technology

Task Number 52

Describe voltage.

Definition

Description should include

- it is the electric potential between two points, such as
    - between the positive and negative poles on a battery
    - two points in an electrical circuit
- it is measured in volts.

Process/Skill Questions

- What is voltage?
- Why do batteries have positive and negative poles?

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12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Task Number 53

Describe electric resistance.

Definition

Description should include

- the amount of opposition the conductor or other elements in a circuit present to the flow of electrons
- that resistance is measured in ohms.

Process/Skill Questions

- What is resistance in electricity?
- What unit is the measure of resistance?

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12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

2. The Core Concepts of Technology

Task Number 54

Explain Ohm's law.

Definition

Explanation should include that

- Ohm's law is the fundamental equation that relates voltage, current, and resistance in a purely resistive circuit according to V (voltage) = I (current) x R (resistance).
- electrical current in a circuit or conductor will always be proportional to the voltage across the conductor or circuit and inversely proportional to the total resistance.

Process/Skill Questions

- What is an equation for Ohm's Law?
- How can current be calculated if resistance and voltage are known?

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12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Task Number 55

Construct a series circuit.

Definition

Construction should include

- a battery
- conductors
- a switch
- a load(s) (e.g., resistors, light bulbs).

A schematic of the circuit should be drawn and the voltage of the circuit measured using a digital multimeter (DMM).

Note: This can be done with circuit software or actual parts.

Process/Skill Questions

- What kind of meter is used to measure voltage in a circuit?
- What makes a series circuit series?

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12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

2. The Core Concepts of Technology

Task Number 56

Construct a parallel circuit.

Definition

Construction should include

- a battery
- conductors
- a switch
- a load(s) (e.g., resistors, light bulbs)
- an extra path wired into the circuit.

A schematic should be drawn of the circuit and the voltage measured across various components using a digital multimeter.

Process/Skill Questions

- Why is a multimeter called that?
- What makes a parallel circuit parallel?

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16. Energy and Power Technologies

2. The Core Concepts of Technology

Task Number 57

Construct circuits that contain resistors.

Definition

Construction should include

- measurement of the resistance of each resistor
- measurement of resistance in the circuit overall using a digital multimeter.

Teacher resource:
- PHET Interactive Simulations

Process/Skill Questions

- Do calculations and multimeters always show the same measurement?

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10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Task Number 58

Apply Ohm's law.

Definition

Application should include the calculation of current, voltage, and resistance in circuits or schematics.

Process/Skill Questions

- How can one calculate voltage if current and resistance are known?
- What is the difference between a schematic and a circuit?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Exploring Turbines

Task Number 59

Exploring Turbines.

Definition

Exploration should include

- gas
- steam
- water
- wind.

Process/Skill Questions

- What are some types of turbines?
- What do all turbines have in common?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 60

Diagram the major components of a gas turbine and explain its purpose.

Definition

Diagram should include

- the components
  - compressor
  - combustor
  - turbine/blades/shaft/vanes
  - casing
- an explanation outlining the overall function of a gas turbine and conversion of chemical potential energy of fuel to thermal energy through combustion
- an explanation outlining the overall function of a gas turbine and conversion of chemical potential energy of fuel and then to mechanical energy by expansion of hot gases through the turbine.

Process/Skill Questions

- What makes a gas turbine turn?
- Would gas turbines turn without heat?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 61

Diagram the major components of a steam turbine and explain its purpose.

Definition

Diagram should include

- the components
    - casing
    - rotor/blades/shaft
- an explanation outlining the overall function of a steam turbine
- conversion of thermal energy of superheated steam to mechanical energy (rotating shaft).

Process/Skill Questions

- How does steam produce mechanical energy?
- What is the purpose of a shaft on a turbine?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 62

Diagram the major components of a water turbine and explain its purpose.

Definition

Diagram should include

- the components
    - water diversion/pipeline
    - turbine/blades/shaft
    - tailrace
- an explanation outlining the overall function of a water turbine
- conversion of mechanical energy associated with moving water to mechanical energy in the form of a rotating turbine and shaft.

Process/Skill Questions

- What is a tailrace?
- What part does mechanical energy play in a water turbine?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 63

Diagram the major components of a wind turbine and explain its purpose.

Definition

Diagram should include

- the components
    - foundation
    - tower
    - rotor (hub/blades)
    - generator
    - yaw mechanism
- an explanation outlining the overall function of a wind turbine
- a conversion of mechanical energy associated with moving air to mechanical energy of rotating blades and shaft driving a generator and conversion to electrical energy.

Process/Skill Questions

- What is a rotor on a wind turbine?
- Why is there a yaw mechanism on a wind turbine?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 64

Compare the characteristics of different types of turbines.

Definition

Comparison should include

- pros and cons
- efficiencies

- operations and maintenance
- scale and/or capacity.

Process/Skill Questions

- What makes one turbine better than another?
- What is a disadvantage of a wind turbine?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Task Number 65

Design a turbine model.

Definition

Design could include

- water, wind, or steam
- computer-aided design (CAD) software (e.g., three-dimensional [3D] model)
- the ability to power motor, light, or another load.

Process/Skill Questions

- What is the first step in the design process?
- What things might determine criteria and constraints of a design?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

16. Energy and Power Technologies

9. Engineering Design

Exploring Generators

Task Number 66

Explain Faraday's law of induction.

Definition

Explanation should include the notion that current is induced through the wire when a coil of wire is exposed to a varying magnetic field.

Process/Skill Questions

- Where does a magnetic field come from?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 67

Describe the fundamental operating principal of a generator.

Definition

Description should include the notion that a generator converts mechanical energy to electrical energy by enabling the rotation of a coil of wire within a stationary magnetic field, thus inducing a current across the wire.

Process/Skill Questions

- How does a generator produce electricity?
- What happens if the magnetic field is reduced?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Task Number 68

Diagram the major components of a generator.

Definition

Diagram should include the components, such as

- housing
- rotor
- stator
- commutator.

Process/Skill Questions

- What is a stator?
- How does a commutator affect a generator?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 69

Explain the difference between a generator and an alternator.

Definition

Explanation should include

- defining *generator* and *alternator*
- addressing the pros, cons, and application of each.

Process/Skill Questions

- How might a generator be superior to an alternator?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Task Number 70

Describe the electrical output of a simple generator and how the power produced can be conditioned.

Definition

Description should include

- the output of a simple generator is alternating current (AC)
- AC power can be passed through a transformer to increase or decrease voltage
- AC power can be passed through an inverter to produce direct current (DC) power.

Process/Skill Questions

- How can AC current be converted to DC?
- What is the purpose of a transformer?

ITEEA National Standards

1. The Characteristics and Scope of Technology

16. Energy and Power Technologies

Exploring Photovoltaics

Task Number 71

Define *photovoltaics* (PV).

Definition

Definition should include the production of electric current at the junction of two substances when exposed to light.

Process/Skill Questions

• What are photovoltaics used for?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 72

Investigate the workings of a solar panel.

Definition

Investigation could include

- photons
- p and n layers
- the electrical behavior of different semi-conductor materials
- cells vs. modules vs. panels
- DC power.

Process/Skill Questions

- What are different types of solar panels?
- What is the typical size of solar module?
- What is the output of power type?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Task Number 73

Compare PV and traditional power sources.

Definition

Comparison should include

- direct generation (e.g., watches, calculators)
- residential generation
- distributed generation
- utility-scale generation.

Comparison should also examine the efficiencies and losses and how DC power is inverted and conditioned.

Process/Skill Questions

- When is solar energy used for direct output?
- Where might traditional power sources be more efficient?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Task Number 74

Describe effects on solar performance.

Definition

Description should include

- siting
- angles
- orientation
- geography
- shading
- solar map interpretation.

Process/Skill Questions

- What factors should be considered when siting solar panels?
- Where does one acquire solar maps?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 75

Design a solar-powered model.

Definition

Design could include

- a house, boat, or car
- a CAD 3D model
- the use of a PV panel for motor, light, or another load.

Process/Skill Questions

- How might a solar panel lift weight using a model?
- How might a vehicle be powered using solar energy?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

Exploring Environmental Effects in Energy and Power

Task Number 76

Explore the effect of greenhouse gas emissions from energy production on the environment.

Definition

Exploration should include

- defining the *greenhouse effect* and *greenhouse gases*
- energy sources that produce greenhouse gas emissions (e.g., methane, carbon dioxide)
    - natural
    - man-made
- effects of greenhouse gas emissions on the environment
    - extreme weather events
    - coastal flooding/sea-level rise
    - destruction of habitats
    - water scarcity
    - public health and conflict.

Process/Skill Questions

- What gases are considered to be greenhouse gases?
- What are the greenhouse effects from energy use?

ITEEA National Standards

16. Energy and Power Technologies

5. The Effects of Technology on the Environment

Task Number 77

Investigate the environmental effects of all energy sources.

Definition

Investigation should include

- air quality effects
    - amount of carbon emission per energy source
    - other emissions from energy production (e.g., sulfur dioxide [SO2], oxides of nitrogen [NOx], mercury)
- water quality effects
    - water usage
    - sulfur oxides (Sox), NOx, mercury, warm water
- wildlife effects
    - habitat destruction and/or fragmentation.

Process/Skill Questions

- What are some effects that energy sources have on the environment?
- How do energy sources effect wildlife?

ITEEA National Standards

16. Energy and Power Technologies

5. The Effects of Technology on the Environment

Task Number 78

Research mitigation techniques for reducing environmental effects from energy sources.

Definition

Research should include

- defining *mitigation*
- decarbonization of energy systems
- wildlife deterrents
- methods of reducing greenhouse gas emissions
- power plants
- policies (e.g., renewable portfolio standards [RPS], carbon tax)
- net-zero emissions energy systems
    - carbon capture
    - electrification
- renewables.

Process/Skill Questions

- What does *mitigation* mean?
- How can mitigation be accomplished?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

5. The Effects of Technology on the Environment

Exploring Health and Safety Challenges in Energy and Power

Task Number 79

Describe health challenges (past, present, and future) posed by and to the energy industry.

Definition

Description should include

- effects on the human population (individual and mass)

- effects on the animal populations (individual and mass)
- effects on the plant and eco-life (individual and mass).

Description should also include remedies for various challenges.

Process/Skill Questions

- What past or present health challenge may be a result of a safety issue?

ITEEA National Standards

1. The Characteristics and Scope of Technology

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

16. Energy and Power Technologies

5. The Effects of Technology on the Environment

Task Number 80

Describe safety challenges (past, present, and future) posed by and to the energy industry.

Definition

Description should include

- effects on the human population (individual and mass)
- effects on the animal populations (individual and mass)
- effects on the plant and eco-life (individual and mass).

Description should also include remedies for various challenges.

Process/Skill Questions

- When would there be a health challenge that would not be a safety challenge?
- What actions can ensure safety of eco-life?

ITEEA National Standards

Task Number 81

Explain the role of regulatory agencies on health and safety.

Definition

Explanation may include

- localities
- state agencies
  - Virginia Department of Environmental Quality (DEQ)
  - Virginia Department of Transportation (VDOT)
  - Virginia Department of Mines, Minerals, and Energy (DMME)
  - Virginia State Corporation Commission (SCC)
  - Virginia Department of Labor and Industry (DOLI) and Virginia Occupational Safety and Health (VOSH) Safety Compliance Division
  - Virginia Department of Health (VDH)
- federal agencies
  - Federal Energy Regulatory Commission (FERC)
  - Rural Utilities Service (RUS)
  - Federal Communications Commission (FCC)
  - Federal Aviation Administration (FAA)
  - Federal Emergency Management Agency (FEMA)
  - U.S. Department of Defense (DOD)
  - U.S. Environmental Protection Agency (EPA)
  - U.S. Nuclear Regulatory Commission (NRC)
  - Occupational Safety and Health Administration (OSHA)
  - Bureau of Ocean Energy Management (BOEM)
  - U.S. Fish and Wildlife Service
  - U.S. Forest Service
  - U.S. Department of Energy
  - U.S. Department of Homeland Security
  - U.S. Army Corps of Engineers
- international
  - North American Electric Reliability Corporation (NERC)
  - International Atomic Energy Agency (IAEA).

Process/Skill Questions

- How can regulatory issues influence the siting of all aspects of the energy life cycle?
- How do regulations influence the energy business and availability?

- Why are regulations important?
- How do agencies overlap?

ITEEA National Standards

1. The Characteristics and Scope of Technology

16. Energy and Power Technologies

Task Number 82

Follow safety guidelines.

Definition

Following guidelines should include

- Occupational Safety and Health Administration (OSHA) guidelines for construction (29 CFR 1926) and general industry (29 CFR 1910)
    - personal protective equipment (PPE)
    - lockout/tagout procedures
    - confined space
    - hearing protection
    - respiratory protection
    - work permits
    - hazardous waste and materials
- manufacturer guidelines for maintenance and use of tools, shop equipment, and equipment
- maintaining lab safety
- National Electrical Code (NEC) National Fire Protection Association (NFPA 70)
- US Chemical Safety and Hazard Investigation Board (CSB) videos
- American Society of Mechanical Engineers (ASME codes)
- National Board of Boiler and Pressure Vessel Inspectors (NBBI codes).

Process/Skill Questions

- What are examples of job site hazards?
- Why is it important to store materials and tools in their proper places?
- What is the purpose of safety data sheets (SDS)?
- What is the unseen hazard with electrical work?
- What is the definition of *proximity work*?
- What are minimum approach distances for qualified and nonqualified workers?

- Why is jewelry not allowed on the work site? Who is authorized to remove a lockout and tagout?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

Task Number 83

Present on health and safety solutions within the industry.

Definition

Presentations may include a diagram, slideshow, video, or demonstration on a health and safety solution, such as

- donning PPE
- lockout/tagout (LOTO)
- routine testing of equipment used within the industry.

Process/Skill Questions

- What is the effect of health and safety solutions on the utility worker, the end-user, or the general public?
- Why was the solution needed?

ITEEA National Standards

16. Energy and Power Technologies

Describing Energy Policy and Trends

Task Number 84

Define *energy policy*.

Definition

Definition should include concepts such as

- energy market (day ahead vs. real time) and planning
- legislation on energy use and standards (emissions)
- legislation on trading and transport
- sustainability
- cybersecurity
- energy security
- energy independence
- energy equity
- health and welfare
- Federal Energy Regulatory Commission (FERC)
- Independent Power Producers (IPP)
- regulated utility
- unregulated utility
- spark spread
- black start capability

Process/Skill Questions

- What is spark spread?
- What does black start capability mean?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 85

Identify environmental, health, and safety aspects of the energy life cycle.

Definition

Identification should include

- habitats
- soil quality
- water quality
- air quality
- worker safety and training
- public health and safety
- waste concerns related to lack of access to energy.

Process/Skill Questions

- What are positive and negative aspects of the energy life cycle?
- What is *energy poverty*?

ITEEA National Standards

16. Energy and Power Technologies

5. The Effects of Technology on the Environment

Task Number 86

Discuss examples of energy efficiency policy and why they are important.

Definition

Discussion may include

- energy efficiency
    - energy and water conservation measures
    - energy management
    - energy measurement and accountability
    - procurement of energy efficient products (e.g., energy star products, LED lighting).
    - energy savings performance contracting
    - demand side management
    - building performance standard (e.g., ASHRAE standards, international energy conservation code)
    - energy assistance and energy equity
        - low-income home energy assistance program
        - weatherization assistance
        - state energy programs

        - energy efficient appliance rebate
        - energy efficient public buildings
    - industry training.

Process/Skill Questions

- Why is energy security important?
- What is *energy equity*?
- Why is energy policy important to achieve net-zero energy goals?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 87

Discuss examples of renewable energy and storage policy and why they are important.

Definition

Discussion should include

- renewable energy and storage policy
    - renewable portfolio standards (RPS)
    - solar
    - wind
    - biomass
    - ocean (including tidal, wave, current, thermal)
    - geothermal
    - hydroelectric
    - energy storage.

Process/Skill Questions

- How is the energy from the ocean stored?
- What policies are in place for each type of renewable energy?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 88

Discuss examples of energy policy and why they are important.

Definition

Discussion should include

- oil and gas
    - petroleum reserve and home heating oil
    - natural gas
    - production
    - incentives
    - procurement
    - market
    - spark spread
    - day-ahead dispatch
    - real-time dispatch
- coal
    - clean coal power initiative
    - clean power projects
    - clean air coal program
- nuclear matters and security
    - Nuclear Regulatory Commission (NRC)
    - decommissioning
    - waste disposal
    - next generation nuclear plant project
    - nuclear facility and materials security
- vehicles and fuels
    - existing programs
    - hybrid vehicles
    - advanced vehicles
    - fuel cell buses
    - clean school buses
    - biodiesel engine testing
    - automobile efficiency
    - fleet procurement
- hydrogen
    - hydrogen and fuel cell programs.

Process/Skill Questions

- Why are policies needed?
- What does day-ahead dispatch mean?
- What is an example of a procurement policy?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 89

Discuss examples of research and development energy policy and why they are important.

Definition

Discussion should include

- energy research, development, demonstration, and commercial application
    - energy efficiency
    - distributed energy and electric energy systems
    - renewable energy
    - agricultural biomass research and development programs
    - nuclear energy
    - fossil energy
    - science
    - coal gasification
    - coal decarbonization
    - ethanol and fuel oils.

Process/Skill Questions

- How does research and development policy affect distributed energy, coal gasification, and nuclear energy?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

16. Energy and Power Technologies

Task Number 90

Discuss examples of other kinds of energy policy and why they are important.

Definition

Discussion should include

- net energy metering
- permit by rule
- tribal energy
    - promotion of tribal energy development, efficiency, and use
    - cost reduction/stabilization
    - infrastructure enhancement
    - electrification
- energy management
- workforce development
- tax incentives and credits.

Process/Skill Questions

- What is net energy metering?
- What policy affects tax incentives?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 91

Analyze challenges that have led to developing new energy policies.

Definition

Analysis may include

- aging infrastructure

- existing generation
- transmission siting
- resiliency and reliability workforce development
- supply and demand
- economics
- transportation
- taxes
- emission standards
- cyber-security.

Process/Skill Questions

- What effect has the aging energy infrastructure had on new energy policy?
- What challenges are faced when transmission siting?

ITEEA National Standards

16. Energy and Power Technologies

4. The Cultural, Social, Economic, and Political Effects of Technology

5. The Effects of Technology on the Environment

6. The Role of Society in the Development and Use of Technology

7. The Influence of Technology on History

Task Number 92

Identify decommissioning and reclamation efforts.

Definition

Identification should include the

- definition of *decommissioning* and *reclamation*
- examples of decommissioning and reclamation efforts.

Process/Skill Questions

- What does decommissioning have to do with the environment?
- Where is there a reclamation effort in Virginia?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 93

Research energy policy trends.

Definition

Research may include a presentation on

- load growth
- investment incentives
- production incentives
- technology research and development
- standards and mandates
- regulatory requirements
- renewable demand
- pollution mitigation
- electrification
- energy storage.

Process/Skill Questions

- What is a trend in load growth?
- What policy trends are currently happening with regulatory requirements?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 94

Investigate career options within the energy sector.

Definition

Investigation may include consideration of

- fields of study and expertise (e.g., engineering, law)
- educational and experience requirements (e.g., trade schools, college, military)
- certification requirements
- salary/compensation
- workforce demand
- trade organizations
- healthcare benefits
- retirement/401K plans.

Process/Skill Questions

- What are some local job opportunities in the energy sector?
- What is the future outlook for careers in the energy sector?
- What are the opportunities for advancement in energy careers?

ITEEA National Standards

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

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SOL Correlation by Task

39	Describe forms of energy and their uses.	English: 9.5, 10.5 History and Social Science: WG.17, WHII.14 Science: PH.7
40	Define *energy*.	English: 9.3, 10.3 Science: PH.5, PH.6, PH.7
41	Identify units of measure.	English: 9.5, 10.5 Science: PH.11
42	Demonstrate energy transformation.	English: 9.5, 10.5 Science: PH.7
43	Explain energy conversion.	English: 9.5, 10.5

		Mathematics: A.1, A.4, A.7, AFDA.1, AFDA.3, AII.3, AII.6, AII.9, MA.2 Science: PH.6, PH.7
44	Identify sources of energy.	English: 9.5, 10.5 History and Social Science: WG.17, WHII.14 Science: PH.6, PH.7
45	Evaluate energy sources that are nonrenewable, renewable, and inexhaustible.	English: 9.3, 10.3 History and Social Science: WG.17, WHII.14 Science: ES.6
46	Diagram the life cycle of energy sources.	English: 9.5, 10.5
47	Analyze byproduct management associated with the use of each.	English: 9.5, 10.5
48	Compare the footprint of various energy sources.	English: 9.5, 10.5 Mathematics: A.8, A.9, AFDA.3, AII.9, PS.1*, PS.2*, PS.3*, PS.4*, PS.7*
49	Explain electric charge.	English: 9.5, 10.5 Science: CH.2, PH.11
50	Describe electric current.	English: 9.5, 10.5 Science: PH.11
51	Explain the difference between conductive and nonconductive material.	English: 9.5, 10.5 Science: PH.11
52	Describe voltage.	English: 9.5, 10.5 Science: PH.11
53	Describe electric resistance.	English: 9.5, 10.5 Science: PH.11
54	Explain Ohm’s law.	English: 9.5, 10.5 Mathematics: A.1, A.4, A.7, AFDA.1, AII.3, AII.6, AII.10 Science: PH.11

55	Construct a series circuit.	Science: PH.11
56	Construct a parallel circuit.	Science: PH.11
57	Construct circuits that contain resistors.	Science: PH.11
58	Apply Ohm's law.	English: 9.5, 10.5, 11.5 Mathematics: A.1, A.4, A.7, AFDA.1, AII.3, AII.6, AII.10 Science: PH.11
59	Exploring Turbines.	English: 9.5, 10.5
60	Diagram the major components of a gas turbine and explain its purpose.	English: 9.5, 10.5 History and Social Science: WG.17, WHII.14
61	Diagram the major components of a steam turbine and explain its purpose.	English: 9.5, 10.5 History and Social Science: WHII.8
62	Diagram the major components of a water turbine and explain its purpose.	English: 9.5, 10.5 History and Social Science: WHII.8
63	Diagram the major components of a wind turbine and explain its purpose.	English: 9.5, 10.5 History and Social Science: WG.17, WHII.14
64	Compare the characteristics of different types of turbines.	English: 9.5, 10.5 History and Social Science: WG.17, WHII.14
65	Design a turbine model.	
66	Explain Faraday's law of induction.	English: 9.5, 10.5 Mathematics: A.1, A.4, A.7, T.1, T.6, AFDA.1, AII.3, AII.6, AII.10
67	Describe the fundamental operating principal of a generator.	
68	Diagram the major components of a generator.	
69	Explain the difference between a generator and an alternator.	English: 9.3, 9.5, 10.3, 10.5 Science: PH.11
70	Describe the electrical output of a simple generator and how the power produced can be conditioned.	English: 9.5, 10.5
71	Define *photovoltaics* (PV).	English: 9.3, 10.3
72	Investigate the workings of a solar panel.	English: 9.5, 10.5
73	Compare PV and traditional power sources.	English: 9.5, 10.5
74	Describe effects on solar performance.	English: 9.5, 10.5

75	Design a solar-powered model.	
76	Explore the effect of greenhouse gas emissions from energy production on the environment.	English: 9.3, 9.5, 10.3, 10.5 History and Social Science: WG.16, WG.17, WHII.14 Science: ES.11
77	Investigate the environmental effects of all energy sources.	English: 9.3, 9.5, 10.3, 10.5 History and Social Science: WG.17, WHII.14
78	Research mitigation techniques for reducing environmental effects from energy sources.	English: 9.8, 10.8 History and Social Science: WG.16, WG.17, WHII.14
79	Describe health challenges (past, present, and future) posed by and to the energy industry.	English: 9.5, 10.5 History and Social Science: WG.16, WG.17, WHII.8, WHII.14
80	Describe safety challenges (past, present, and future) posed by and to the energy industry.	English: 9.5, 10.5 History and Social Science: WG.16, WG.17, WHII.8, WHII.14
81	Explain the role of regulatory agencies on health and safety.	English: 9.5, 9.8, 10.5, 10.8
82	Follow safety guidelines.	English: 9.5, 9.8, 10.5, 10.8
83	Present on health and safety solutions within the industry.	English: 9.5, 10.5
84	Define *energy policy*.	English: 9.3, 9.5, 10.3, 10.5
85	Identify environmental, health, and safety aspects of the energy life cycle.	English: 9.5, 10.5
86	Discuss examples of energy efficiency policy and why they are important.	English: 9.1, 10.1, 12.1
878	Discuss examples of renewable energy and storage policy and why they are important.	English: 9.1, 10.1, 12.1 History and Social Science: GOVT.8 Science: ES.6
88	Discuss examples of energy policy and why they are important.	English: 9.1, 10.1
89	Discuss examples of research and development energy policy and why they are important.	English: 9.1, 10.1
90	Discuss examples of other kinds of energy policy and why they are important.	English: 9.1, 10.1
91	Analyze challenges that have led to developing new energy policies.	English: 9.5, 10.5, 11.5, 12.5

92	Identify decommissioning and reclamation efforts.	English: 9.3, 9.5, 10.3, 10.5
93	Research energy policy trends.	English: 9.5, 10.5
94	Investigate career options within the energy sector.	English: 9.5, 10.5

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- College and Work Readiness Assessment (CWRA+)
- Energy Industry Fundamentals Certificate Assessment
- National Career Readiness Certificate Assessment
- Workplace Readiness Skills for the Commonwealth Examination

Concentration sequences: *A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.*

- Power Generation Design and Function (PG8411/36 weeks)

Career Cluster: Energy	
Pathway	**Occupations**
Energy Efficiency	**Electrical Engineer** **Electrician** **Environmental Engineer** **Environmental Engineering Technician** **Environmental Science and Protection Technician** **Environmental Scientist** **Geoscientist** **HVAC and Refrigeration Mechanic or Installer**
Fuels Production	**Chemical Engineer** **Chemist** **Continuous Mining Machine Operator** **First-Line Supervisor of Transportation and Material-Moving Machine and Vehicle Operator** **Geological Technician** **Petroleum Engineer** **Petroleum Technician**

Career Cluster: Energy	
Pathway	**Occupations**
	Service Unit Operator, Oil, Gas, and Mining **Wellhead Pumper**
Power Generation	**Control and Valve Installer, Repairer** **Electrical Engineering Technician** **Electronics Engineer** **Electronics Engineering Technician** **Engineering Manager** **Health and Safety Engineer** **Mechanical Engineer** **Nuclear Engineer** **Nuclear Power Reactor Operator** **Nuclear Technician** **Solar Photovoltaic Installer**
Transmission and Distribution	**Electrical and Electronics Repairer, Powerhouse, Substation and Relay** **Electrical Power Line Installer/Repairer** **Electro-Mechanical Technician** **Gas Compressor and Gas Pumping Station Operator** **Pipefitter, Steamfitter** **Plumber** **Power Distributor, Dispatcher** **Wind Turbine Service Technician**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Civil Engineer** **Civil Engineering Technician** **Computer Hardware Engineer** **Computer Programmer** **Computer Software Engineer** **Electrical Drafter** **Electrical Engineer** **Electrical Engineering Technician** **Electro-Mechanical Technician** **Electronic Drafter** **Electronics Engineering Technician** **Environmental Engineer** **Mechanical Drafter** **Mechanical Engineer** **Mechanical Engineering Technician** **Network and Computer Systems Administrator** **Network Systems and Data Communication Analyst** **Nuclear Engineer** **Petroleum Engineer** **Pipeline Drafter** **Power Systems Engineer** **Project Manager** **Quality Engineer** **Quality Technician**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
	Statistician **Systems Analyst** **Transportation Manager**
Science and Mathematics	**Chemist** **Ecologist** **Environmental Scientist** **Geodetic Surveyor** **Geoscientist** **Occupational Health and Safety Specialist** **Research Chemist**

Career Cluster: Transportation, Distribution and Logistics	
Pathway	**Occupations**
Health, Safety and Environmental Management	**Health, Safety, and Environment Manager**
Logistics Planning and Management Services	**Logistics Analyst** **Logistics Engineer** **Logistics Manager**
Transportation Systems/Infrastructure Planning, Management and Regulation	**Civil Engineer** **Civil Engineering Technician** **Transportation Manager**