Renewable Energy

8408 36 weeks

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Office of Career, Technical, and Adult Education
Virginia Department of Education

Course Description

Suggested Grade Level: 10 or 11 or 12

Renewable energy sources are steadily becoming more important in the global economy as nations strive to replace fossil fuels with eco-friendly power. In this course, students will explore select renewable energy technologies, gain hands-on experience in their design and function, and practice installation skills.

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	8408	Tasks/Competencies
Examining Energy and Power		
39	⊕	Explain the fundamental relationship between potential and kinetic energy.
40	⊕	Demonstrate how batteries/cells function.
41	⊕	Record battery charge and discharge rates in a data table.
42	⊕	Use a multimeter to measure current, amps, voltage, and resistance in various direct current (DC) and alternating current (AC)energy systems.
43	⊕	Create series and parallel circuits.
44	⊕	Apply Ohm’s law to determine the level of current flowing in a circuit.
45	⊕	Describe the uses of AC and DC.
46	⊕	Explain the concept of phantom loads and their associated costs.
47	⊕	Estimate wattage.
Understanding Energy Issues		
48	⊕	Identify fossil fuels and their uses.
49	⊕	Explain the process of global climate change.
50	⊕	Create a video that explains the differences among renewable, inexhaustible, and non-renewable energy sources.

51	⊕	Compare governmental policy and support for the fossil-fuel vs. the clean-energy economy.	
Conserving Energy			
52	⊕	Explain inefficiencies of modern energy systems.	
53	⊕	Describe various governmental initiatives and incentives to boost energy efficiency.	
54	⊕	Explain the societal, environmental, and economic advantages of energy conservation.	
55	⊕	Describe how energy is used within various sectors of society.	
56	⊕	Conduct an energy audit of the local school building.	
57	⊕	Compute the energy savings that can be realized by modifying the building or energy-use patterns.	
58	⊕	Describe ways to test the integrity of a residential building's shell.	
59	⊕	Explain the recommended levels of insulation for local residential structures using the R-value system.	
60	⊕	Explain how windows and doors affect the energy efficiency of a home.	
61	⊕	Describe various water heating systems used in residential buildings and the advantages and disadvantages of each.	
Examining Fuel Cells			
62	⊕	Explain the theory of a hydrogen economy.	
63	⊕	Explain covalent bonding and its association with fuel cell technology.	
64	⊕	Explain the advantages and disadvantages of various methods of producing and transporting hydrogen.	
65	⊕	Explain the infrastructure challenges to fuel cells becoming a widely adopted technology.	
66	⊕	Demonstrate the operation of a hydrogen fuel cell.	
67	⊕	Define *fuel cell stack.*	

68	⊕	Diagram the connection of fuel cell stacks to produce various amounts of power at specific voltages.	
69	⊕	Identify the various types of fuel cells.	
70	⊕	Compare PEM fuel cell and internal combustion engine (ICE) efficiencies.	
71	⊕	Identify the components of a complete PEM fuel cell system.	
72	⊕	Compare the three major categories of fuel cell systems: stationary fuel cells, fuel cell vehicles, and portable fuel cells.	
73	⊕	Research whether fuel cell technology is a realistic alternative to fossil fuels.	
Exploring Passive Solar Power Systems			
74	⊕	Explain the differences between passive and active solar systems.	
75	⊕	Design examples of daylighting systems.	
76	⊕	Explain the relationship of thermal mass to the storage of heat energy.	
77	⊕	Calculate the thermal storage capacity of various building materials.	
78	⊕	Explain direct, indirect, and isolated solar gain in passive solar power systems in buildings.	
79	⊕	Describe the advantages and disadvantages of various solar thermal-heating systems.	
80	⊕	Complete a needs assessment, system sizing, and selection process for a residential solar thermal system.	
81	⊕	Describe the use of passive solar cooling systems in residential buildings.	
Exploring Active Solar Power Systems			
82	⊕	Explain the underlying principles of photovoltaic systems (PV) and factors that affect system efficiency.	
83	⊕	Describe advantages and disadvantages of various PV system configurations.	
84	⊕	Design a residential PV system to show the function of its components.	

Installing Photovoltaic Systems			
85	⊕	Explain the functions of the major PV system components in residential structures.	
86	⊕	Explain issues related to the mounting of PV systems on a variety of structures.	
87	⊕	Assemble a model of a PV array.	
88	⊕	Measure PV array energy output under various conditions.	
89	⊕	Create a model vehicle powered by solar energy.	
90	⊕	Present solar panel specifications, benefits to type of panel chosen, costs, and benefits for a variety of system designs.	
91	⊕	Connect a PV array to storage batteries.	
92	⊕	Use a PV array to supply an AC load and a DC load.	
93	⊕	Calculate the system cost and payback period for a solar PV installation.	
94	⊕	Explain local solar power regulations and legislation.	
95	⊕	Complete a site analysis of various locations for PV installations.	
Examining Wind Power			
96	⊕	Explain global wind patterns and their causes.	
97	⊕	Create a map of local, national, and global wind patterns, noting areas where wind turbines are widely used.	
98	⊕	Explain the effect of ground surface features on wind speed.	
99	⊕	Explain the advantages and disadvantages of wind-powered electrical systems.	
100	⊕	Describe Betz's law and the conservation of energy.	
101	⊕	Identify the issues facing the widespread adoption of utility-scale wind energy production.	
Installing Wind Power Systems			

102	⊕	Research the function of the basic components in a residential-scale wind power system.	
103	⊕	Explain the aerodynamic principles that affect wind turbine performance, specifically with regard to rotor blade design.	
104	⊕	Explain horizontal and vertical wind turbine design and the advantages and disadvantages of each.	
105	⊕	Explain the three scales of wind turbines and the applications for each.	
106	⊕	Describe the different types of materials that are used in wind turbine construction.	
107	⊕	Compare various wind turbine designs for their capabilities in generating electricity.	
108	⊕	Explain the various methods wind turbines employ to control wind speeds.	
109	⊕	Recommend the appropriate wind power system design (e.g., stand-alone, grid-tied, hybrid) for a customer's needs.	
110	⊕	Complete a site analysis for a potential wind power system.	
111	⊕	Demonstrate the mounting of a model wind turbine system.	
112	⊕	Analyze the basic operation and output of a wind turbine.	
113	⊕	Observe the operation of a wind turbine connected to a DC load.	
114	⊕	Correlate wind power, speed, and electrical output of a wind turbine system.	
115	⊕	Locate wind turbine regulations and legislation.	
116	⊕	Explain the factors to consider when siting a utility-scale wind farm.	
Examining Biomass and Biofuels			
117	⊕	Explain the difference between biomass and biofuels.	
118	⊕	Create a model of the carbon cycle.	
119	⊕	Describe the carbon cycle's relationship to greenhouse gas levels in the atmosphere.	

120	⊕	Explain how biomass is converted into usable energy.	
Exploring Energy Use in Transportation			
121	⊕	Explain fossil fuels' role in the global economy.	
122	⊕	Identify alternatives to the current fossil-fuel based transportation system.	
123	⊕	Research how freight is moved and the alternatives that will reduce this sector’s demand for fossil fuels.	
124	⊕	Create a timeline of the history of transportation.	
125	⊕	Explain the advantages and disadvantages associated with EVs.	
126	⊕	Compare the various battery technologies used in the EV industry.	
127	⊕	Describe how EVs work.	
128	⊕	Compare the types of hybrid and EVs.	
129	⊕	Examine current mass transit systems in the United States.	
130	⊕	Identify transportation options that may prove practical for mass transit.	
131	⊕	Explain how EVs could be used to supplement a smart grid with energy storage.	
Understanding Hydropower			
132	⊕	Describe the role of hydropower in current energy production.	
133	⊕	Explain how a river’s head and water pressure are related.	
134	⊕	Explain how water is distributed in different municipalities.	
135	⊕	Identify the advantages and disadvantages of using water as a power source.	
136	⊕	Identify the steps necessary to perform a site assessment of a micro-hydro project.	
137	⊕	Calculate the power contained in a specific hydro source, given the flow and head of the stream or river.	

138	⊕	Identify the factors (other than available power) that must be considered when determining the viability of a specific micro-hydro site.	
139	⊕	Create a model of a micro-hydropower system.	
140	⊕	Explain how the various micro-hydro turbines/generators work.	
141	⊕	Explain the unique safety and maintenance issues involved in installing and operating a micro-hydropower system.	
Examining Geothermal Energy			
142	⊕	Describe high- and low-temperature geothermal systems.	
143	⊕	Describe how different geothermal energy systems are used to meet energy demands.	
Examining Hydrokinetic Energy			
144	⊕	Explain how tidal energy can be used to generate electricity.	
145	⊕	Investigate the latest technologies and system designs being used to harness tidal energy.	
146	⊕	Explain how wave and tidal energy can be used to generate electricity.	
147	⊕	Investigate the latest technologies and system designs being used to harness wave and tidal energy.	
148	⊕	Experiment with capturing wave energy.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

Examining Energy and Power

Task Number 39

Explain the fundamental relationship between potential and kinetic energy.

Definition

Explanation should include

- defining potential energy
- defining kinetic energy
- providing examples of potential energy and kinetic energy.

Process/Skill Questions

- How does a spring demonstrate potential and kinetic energy?
- How do a battery, spring, ball, and pendulum demonstrate the conversion between potential and kinetic energy?
- How do sunlight and wind demonstrate potential and kinetic energy?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 40

Demonstrate how batteries/cells function.

Definition

Demonstration should include assembling a basic circuit that includes a battery/cell, wires, and load.

Process/Skill Questions

- How is the separation of electrical charges fundamental to the function of a battery/cell?
- How are materials with different electrical charges combined to make a battery/cell?

- What are the similarities and differences in different battery types (e.g., lithium, alkaline, nickel-cadmium)?

Common Career Technical Core

ST-SM1
Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 41

Record battery charge and discharge rates in a data table.

Definition

Recording should include

- measuring charge and discharge rates
- entering rates in a data table.

Process/Skill Questions

- How does a cell phone or laptop discharge at different rates based on use or settings?
- How does a lithium ion battery discharge compared with an alkaline or a dry-cell battery discharge?

Common Career Technical Core

ST2
Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 42

Use a multimeter to measure current, amps, voltage, and resistance in various direct current (DC) and alternating current (AC)energy systems.

Definition

Use should include configuring the meter and applying settings to measure voltage (electrical potential), current (flow of charge), and resistance (opposition to flow of charge).

Process/Skill Questions

- What is the difference among the amps, current, voltage, and resistance measures between a series and parallel circuit?
- How do volts change when measuring a series vs. a parallel circuit configuration?
- How are amps affected when comparing a series and parallel circuit?

Common Career Technical Core

ST2
Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 43

Create series and parallel circuits.

Definition

Creation should include

- explaining the difference between series and parallel circuits
- stating when each is appropriate to use
- assembling functional circuits using wires, load, and voltage source.

Process/Skill Questions

- How do different circuit configurations affect electrical output?
- What circumstance make a series circuit preferable to a parallel configuration?
- What situation would make a parallel design preferable to using a series circuit design?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 44

Apply Ohm's law to determine the level of current flowing in a circuit.

Definition

Application should include defining

- *current*–measured in amperes
- *voltage*–measured in volts
- *resistance*–measured in ohms.

Process/Skill Questions

- How is Ohm's law used to solve for any single unknown when the other two values are known?
- How do voltage, current, and resistance change over distance traveled?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 45

Describe the uses of AC and DC.

Definition

Description should include

- defining *alternating current* and *direct current*
- providing examples of the use of each.

Process/Skill Questions

- How does a mobile device use both AC and DC?
- What are some common uses of AC?
- When is the use of DC more practical?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 46

Explain the concept of phantom loads and their associated costs.

Definition

Explanation should include

- defining *phantom load*
- identifying examples of phantom loads and their associated costs.

Process/Skill Questions

- What percentage of an average electricity bill is a result of phantom loading?
- What is the estimated phantom load of a desktop central processing unit (CPU) compared with the phantom load measured by a given energy meter?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 47

Estimate wattage.

Definition

Estimation should include determining the amount of wattage used by household appliances powered by AC.

Process/Skill Questions

- How can a kilowatt meter be used to analyze plug load?
- How can one reduce the use of electricity after analyzing plug load data?
- How can one use Energy Star ratings to choose appliance replacements for a given product?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
ST2
Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

16. Energy and Power Technologies

Understanding Energy Issues

Task Number 48

Identify fossil fuels and their uses.

Definition

Identification should include

- coal used for electricity
- oil used for transportation and feedstocks (e.g., manufacturing plastics)
- natural gas used for electricity and heating.

Process/Skill Questions

- Where are fossil fuels (i.e., hydrocarbons) found?
- How are fossil fuels used?
- Why do people refer to fossil fuels as ancient sunlight?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 49

Explain the process of global climate change.

Definition

Explanation should include using scientific data such as

- global temperature change over an extended period of time

- ocean acidification
- weather pattern changes (e.g., desertification, flood patterns, sea-level rise, drought).

Process/Skill Questions

- What are some reliable sources for scientific data? (e.g., EPA, NOAA, NASA)
- How does geospatial technology represent the data?
- What does the Intergovernmental Panel on Climate Change report in its latest work?
- How can renewable energies play a role in combating climate change?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

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

5. The Effects of Technology on the Environment

Task Number 50

Create a video that explains the differences among renewable, inexhaustible, and non-renewable energy sources.

Definition

Creation should include a definition of *renewable*, *inexhaustible*, and *nonrenewable* energy sources and provide examples of each:

- Renewable
    - Animal
    - Food
    - Wood
    - Biomass
- Inexhaustible
    - Solar
    - Wind
    - Geothermal

    - Hydropower
    - Hydrokinetic
- Nonrenewable
    - Coal
    - Oil
    - Natural gas
    - Nuclear

Process/Skill Questions

- What is the role of time in forming energy sources?
- What are examples of renewable energy sources and examples of nonrenewable energy sources?
- What is meant by *clean energy*?
- Why are hydrocarbons considered nonrenewable?
- What is an inexhaustible resource?
- How is the sun the main source of all renewable and most inexhaustible energy?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 51

Compare governmental policy and support for the fossil-fuel vs. the clean-energy economy.

Definition

Comparison should include

- governmental subsidies for each
- roles of various levels of government (i.e., local, state, federal)
- approaches to reforming policy and building code to support renewables.

Process/Skill Questions

- What types of subsidies are provided to an oil company when building a new drilling rig as compared to companies who are installing utility scale solar or wind systems?
- What tax breaks or incentives are provided to an oil company when building a new drilling rig as compared to companies who are installing utility-scale solar or wind systems?
- What legislative proposals have been made, passed, or defeated to attempt to balance subsidies for the fossil fuel and clean energy companies?

Common Career Technical Core

ST4
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

ITEEA National Standards

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

5. The Effects of Technology on the Environment

Conserving Energy

Task Number 52

Explain inefficiencies of modern energy systems.

Definition

Explanation should include the aging electric grid, difficulty incorporating renewable energy systems, inability to store energy that is generated for use at another time.

Process/Skill Questions

- What challenges are facing the current energy grid system?
- What is the smart grid?
- What is the microgrid?
- Why are renewable energy sources difficult to integrate into the grid system?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 53

Describe various governmental initiatives and incentives to boost energy efficiency.

Definition

Description should include

- tax incentives
- financing opportunities
- private investing.

Process/Skill Questions

- What are the tax rebates available for energy efficient windows and doors?
- According to the Database of State Incentives for Renewable Energy (DSIRE) website, what are the available tax incentives in Virginia for buying ENERGY STAR appliances?

Common Career Technical Core

ST4
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

ITEEA National Standards

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

5. The Effects of Technology on the Environment

Task Number 54

Explain the societal, environmental, and economic advantages of energy conservation.

Definition

Explanation should include

- Organization of the Petroleum Exporting Countries (OPEC)
- acid rain, greenhouse effect, global warming
- recycling
- forms of energy.

Process/Skill Questions

- What are some outcomes of efforts to conserve energy?
- What environmental effect do changes in use of energy sources have?
- What role does economics play in the efforts to conserve energy?

Common Career Technical Core

ST4
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

ITEEA National Standards

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

5. The Effects of Technology on the Environment

Task Number 55

Describe how energy is used within various sectors of society.

Definition

Description should include

- manufacturing energy and power technologies
- medical technologies
- transportation technologies.

Process/Skill Questions

- How are most manufacturing and power technologies using energy currently?
- How are transportation technologies changing the way consumers consider energy use?

Common Career Technical Core

ST4
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

ITEEA National Standards

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

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Task Number 56

Conduct an energy audit of the local school building.

Definition

Conducting an energy audit should include

- electronics that are left plugged in, such as
    - computers
    - printers
    - interactive whiteboards
    - copiers.

Survey should include

- lighting
- water heating
- heating and cooling system
- observations of weather-stripping conditions.

Process/Skill Questions

- What are the metrics for calculating the annual cost of a given device's phantom consumption of electric energy?
- How much energy does a given device consume if it is left in hibernation mode for 24 hours?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 57

Compute the energy savings that can be realized by modifying the building or energy-use patterns.

Definition

Computation should include

- identifying sources of high-energy use.
- identifying aberrant energy loads.
- comparing with similar student use.
- demonstrating the success or failure of efficiency improvements.
- engaging students in thinking about their energy consumption.

Process/Skill Questions

- How many watts of electricity does it take to cook a 14-pound turkey?
- How many watts of electricity does the average desktop computer consume in 24 hours?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 58

Describe ways to test the integrity of a residential building's shell.

Definition

Description should include

- the home as a system: how the building shell acts as a series of individual systems and interacts with the foundation and ventilation
- the most common sources of indoor air pollution resulting from material options and construction of the building shell (framing, roof, insulation, durable exterior details, etc.) and their effect on occupant health
- the physical processes and building science concepts in new and existing homes (e.g., air flow, pressure, moisture migration, outgassing)
- practical strategies to construct or renovate the building shell to minimize indoor air quality problems
- examples of common or promising wall and roof types in new construction and renovation, including sample material types
- how product selection and installation can affect the function of building shell components
- the balancing of energy efficiency and indoor air quality.

Process/Skill Questions

- How can a building affect indoor air quality?
- What are some building science concepts that can improve new and existing homes?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 59

Explain the recommended levels of insulation for local residential structures using the R-value system.

Definition

Explanation should include

- the location of a specific home
- the age of a specific home
- radiant barriers
- reflective insulation systems
- insulation calculator
- the types of insulation
- moisture control
- air leaks.

Process/Skill Questions

- Why must moisture be considered when planning the insulation of a building?
- What are the most common locations for air leaks in older homes?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

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Task Number 60

Explain how windows and doors affect the energy efficiency of a home.

Definition

Explanation should include

- window types
- door types
- R-value
- window coverings
- lighting (i.e., natural vs. man-made light sources).

Process/Skill Questions

- What is the comparison of the R-value of various window types?
- How does passive solar heat gain affect energy consumption?
- How does weather stripping affect air infiltration?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

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Task Number 61

Describe various water heating systems used in residential buildings and the advantages and disadvantages of each.

Definition

Description should include

- heat pump

- hydronic heating
- geothermal
- fossil fuels (i.e., natural gas, oil, coal).

Process/Skill Questions

- What are some advantages and disadvantages of using fossil fuels to heat water?
- What is hydronic heating?
- When might geothermal environment control be a good option for home owners?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

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

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Examining Fuel Cells

Task Number 62

Explain the theory of a hydrogen economy.

Definition

Explanation should include social, economic, and environmental advantages and challenges of hydrogen energy systems. Advantages and challenges are associated with

- generation
- storage
- distribution
- use
- infrastructure.

Process/Skill Questions

- How could the hydrogen economy affect current energy challenges around the world?
- How can the theory be explained so that mankind can learn how to take hydrogen and use it to generate clean power, when the methods for liberating hydrogen are not clean?
- What is steam methane reformation (SMR)?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 63

Explain covalent bonding and its association with fuel cell technology.

Definition

Explanation should include the process of breaking the covalent bond in water to separate oxygen and hydrogen.

Process/Skill Questions

- What is covalent bonding?
- What is the ratio of hydrogen to oxygen when the covalent bond in H_2O is broken?

Common Career Technical Core

ST-SM1
Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.

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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Task Number 64

Explain the advantages and disadvantages of various methods of producing and transporting hydrogen.

Definition

Explanation should include current research on hydrogen production, storage, and transportation.

Process/Skill Questions

- What are the safety concerns associated with producing, storing, and transporting hydrogen?
- What are the byproducts of hydrogen production?
- Which fuels cells are most viable for transportation uses?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 65

Explain the infrastructure challenges to fuel cells becoming a widely adopted technology.

Definition

Explanation should include challenges to developing the infrastructure necessary for production, storage, and distribution of hydrogen, such as

- development of safety regulations
- infrastructure design and economic effect.

Process/Skill Questions

- What are the differences between centralized and decentralized hydrogen production?
- What type of fuel powers the transportation of goods and materials?
- How is hydrogen stored?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

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Task Number 66

Demonstrate the operation of a hydrogen fuel cell.

Definition

Demonstration should include powering a load with a hydrogen fuel cell.

Process/Skill Questions

- What is the energy output for one pound of hydrogen?
- What is electrolysis?
- How would one measure the length of time needed to capture a specific amount of carbon?

Common Career Technical Core

ST-SM1
Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.
ST-SM2

Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
ST2
Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 67

Define *fuel cell stack.*

Definition

Definition should cite that a *fuel cell stack* is a set of fuel cells connected in parallel to produce a desired amount of power.

Process/Skill Questions

- What is a fuel cell stack?
- How do fuel cell stacks help solve the challenges in hydrogen energy adoption?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 68

Diagram the connection of fuel cell stacks to produce various amounts of power at specific voltages.

Definition

Diagram should render a model of a circuit using interconnected fuel cell stacks.

Process/Skill Questions

- How does stacking fuel cells in parallel affect output in volts and amps?

- How does connecting fuel cells in series affect output in volts and amps?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

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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Task Number 69

Identify the various types of fuel cells.

Definition

Identification should include

- proton exchange membrane (PEM)
- alkaline
- direct methanol
- molten carbonate
- phosphoric acid
- solid oxide
- regenerative
- zinc air
- microbial.

Process/Skill Questions

- Which types of fuel cells are most powerful in terms of energy produced?
- Which cells produce the most heat as a byproduct?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 70

Compare PEM fuel cell and internal combustion engine (ICE) efficiencies.

Definition

Comparison should include the collection and analysis of data using charts and graphs to determine the efficiency of each.

Process/Skill Questions

- Are fuel cells more or less durable than an ICE?
- What are the maintenance costs of PEM compared to ICE?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 71

Identify the components of a complete PEM fuel cell system.

Definition

Identification should include

- anode
- cathode

- membrane
- catalyst
- housing/structure
- electrolyte.

Process/Skill Questions

- What is the membrane of a PEM?
- What is the largest expense in a PEM?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 72

Compare the three major categories of fuel cell systems: stationary fuel cells, fuel cell vehicles, and portable fuel cells.

Definition

Comparison should include the similarities and differences among the three categories, including

- application
- life span
- reliability.

Process/Skill Questions

- Why are stationary fuel cells stationary?
- What are the primary challenges in transportation fuel cell designs?

Common Career Technical Core

ST-SM4

Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 73

Research whether fuel cell technology is a realistic alternative to fossil fuels.

Definition

Research should include a life-cycle analysis of

- generation
- storage
- distribution
- use
- infrastructure
- efficiency
- disposal.

Process/Skill Questions

- What are some difficulties in producing fuel cells?
- Why are fuel cells not in wide use at this time?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

Exploring Passive Solar Power Systems

Task Number 74

Explain the differences between passive and active solar systems.

Definition

Explanation should include

- defining *passive solar system* and *active solar system*
- identifying uses of passive solar (e.g., daylighting, heating) and active solar (e.g., converting radiant or thermal energy into electricity).

Process/Skill Questions

- How can passive and active solar systems be used in green-built structures?
- What are some considerations in the application of solar systems?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 75

Design examples of daylighting systems.

Definition

Design should include technical drawings or sketches with symbols to indicate the placement of

- light shelves
- windows
- skylights
- smart window technology
- solar tubes.

Process/Skill Questions

- How do daylighting systems reduce electricity consumption?
- How do light shelves work?
- What are benefits of smart window technology?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 76

Explain the relationship of thermal mass to the storage of heat energy.

Definition

Explanation should include

- defining *thermal mass*
- defining *BTUs*
- describing how thermal mass affects temperature change.

Process/Skill Questions

- How does thermal mass help regulate temperature in the built environment?

- How are radiation, convection, and conduction related to thermal mass?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

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

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Task Number 77

Calculate the thermal storage capacity of various building materials.

Definition

Calculation should include measuring the temperature of a thermal mass over time to determine how it stores and releases thermal energy.

Process/Skill Questions

- What building materials are most effective in storing thermal energy?
- What is the relationship between R-value and U-value?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
ST2
Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

16. Energy and Power Technologies

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

Task Number 78

Explain direct, indirect, and isolated solar gain in passive solar power systems in buildings.

Definition

Explanation should include

- defining *direct, indirect*, and *isolated solar gain*
- identifying examples of each.

Process/Skill Questions

- What considerations influence the choice to use direct, indirect, or isolated solar gain?
- How can the use of direct, indirect, and isolated solar gain be used to offset energy consumption?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 79

Describe the advantages and disadvantages of various solar thermal-heating systems.

Definition

Description should include advantages and disadvantages of

- solar thermal water heating

- radiant floor heating.

Process/Skill Questions

- What is the payback period for solar thermal water heating?
- What are the advantages of radiant floor heating compared to conventional air-to-air exchange systems?
- What role does geography play in the efficacy of solar thermal water or floor heating?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

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Task Number 80

Complete a needs assessment, system sizing, and selection process for a residential solar thermal system.

Definition

Completion should include

- building orientation
- site preparation
- geographic location
- demand/application
- available roof area and age of roof
- familiarity with solar siting equipment (e.g., pyranometer, solar pathfinder).

Process/Skill Questions

- What considerations and information should be used in a needs assessment for solar thermal energy?
- What are the criteria for sizing a residential solar thermal system?

- How would raising the number of household members by three persons affect a needs-assessment outcome?

Common Career Technical Core

ST-SM1
Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.
ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
ST2
Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

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Task Number 81

Describe the use of passive solar cooling systems in residential buildings.

Definition

Description should include natural convection currents and the use of chimneys to move warmer and cooler air. Components of a passive solar cooling system may include

- shading
- reflectors
- chimneys
- earth tubes
- cooling towers
- earth-sheltered homes
- built ventilation systems.

Process/Skill Questions

- How can planting trees decrease the cooling cost for a business?

- What is the average temperature of the earth at five feet deep?
- How does a light shelf reduce cooling loads?
- How does natural convection play a role in cooling?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Exploring Active Solar Power Systems

Task Number 82

Explain the underlying principles of photovoltaic systems (PV) and factors that affect system efficiency.

Definition

Explanation should include

- photons
- polarity within a PV cell
- DC current
- basic atomic structure.

Process/Skill Questions

- What is the photovoltaic effect?
- How does a PV cell work?
- What are insolation and irradiance
- What are the three most common types of PV panels?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 83

Describe advantages and disadvantages of various PV system configurations.

Definition

Description should include

- electrical output
- load estimates
- cost of installation
- system expectations from the customer
- tax credits
- finance models (e.g., solar co-ops)
- net metering.

Process/Skill Questions

- What are the advantages/disadvantages of a grid-tied PV system?
- What are the advantages/disadvantages of an off-grid PV system? When should someone use battery back-up in a PV system design?
- What is net metering, and how does it work in Virginia?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

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Task Number 84

Design a residential PV system to show the function of its components.

Definition

Design should include

- a site analysis
- customer input
- building load
- percent of electrical use covered
- type of solar panel chosen
- number and type of inverters selected
- mounting system
- disconnect switches
- other safety or monitoring materials (if required), batteries (if required), and charge controllers (if required).

Process/Skill Questions

- How many kilowatts of electricity does the average home in the local community consume on average per month?
- What is the conversion calculation from kilowatt hours consumed and kilowatts produced?
- What size solar array would be needed to power the average home in the local community?
- What are the three most common racking systems for solar PV?
- What size inverter would be needed to handle a PV array that could power the average home in the local community?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

ITEEA National Standards

16. Energy and Power Technologies

Installing Photovoltaic Systems

Task Number 85

Explain the functions of the major PV system components in residential structures.

Definition

Explanation should cover

- solar cells
- solar panels
- mounting systems
- disconnect switches
- inverters
- monitoring systems (if applicable), batteries (if applicable), and charge controllers (if applicable).

Process/Skill Questions

- What is a solar model?
- What does an inverter do?
- What is a charge controller?
- What is a micro-inverter?
- What is a racking system?
- What are the advantages to a pole-mounting system?

- What size batteries are typically used in PV back-up system?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 86

Explain issues related to the mounting of PV systems on a variety of structures.

Definition

Explanation should include advantages and disadvantages of roof, pole, and ground-mount systems, and tracking systems.

Process/Skill Questions

- What is wind loading?
- How does heat affect PV panel output?
- What is a passive tracking system?
- What is an active tracking system?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 87

Assemble a model of a PV array.

Definition

Assembly should involve

- panels
- series and parallel circuit designs
- inverter
- mounting system
- charge controller
- battery.

Process/Skill Questions

- What are the results of wiring a PV array in series compared to in parallel?
- What are the benefits of a ground-mounting system compared to a roof-mounted system?
- What could be the result if the charge controller failed?
- What are the considerations when choosing the type of solar panel to incorporate into a PV system?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
ST2
Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 88

Measure PV array energy output under various conditions.

Definition

Measurement should include voltage, amps, and watts (if possible).

Process/Skill Questions

- What happens to the output of a PV array when it is exposed to different colors of light?
- What happens to the output of a PV array when the angle of light is changed?
- How does one set a multimeter to measure the output from a PV array?
- How is output affected by shading and light intensity?

Common Career Technical Core

ST-SM1
Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.
ST2
Use technology to acquire, manipulate, analyze and report data.

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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Task Number 89

Create a model vehicle powered by solar energy.

Definition

Creation should include

- documentation of possible solutions, including sketches
- connection of a solar array to a vehicle
- a vehicle that moves powered by solar/light energy.

Process/Skill Questions

- What might a solar vehicle need besides a solar array?
- Why power a vehicle using solar power?

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16. Energy and Power Technologies

Task Number 90

Present solar panel specifications, benefits to type of panel chosen, costs, and benefits for a variety of system designs.

Definition

Presentation should include a detailed budget sheet, warranties, and system payback analysis.

Process/Skill Questions

- What questions would a client likely have about cost and payback-period for a solar PV installation?
- What would a consumer need to know to make an informed decision about installing a solar array?
- What are the advantages and disadvantages to using the different types of solar arrays in a PV system?
- What is the payback period for a 5-kilowatt system in the local area?
- What is the average installation cost for a -5-kilowatt system?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

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Task Number 91

Connect a PV array to storage batteries.

Definition

Connection should involve different array wiring configurations, using a charge controller and battery capacity.

Process/Skill Questions

- Where should one start to troubleshoot a PV system installation if something is not working properly?
- What are the most important factors in making electrical connections?
- What is a short circuit?

Common Career Technical Core

ST-SM1
Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.
ST2
Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 92

Use a PV array to supply an AC load and a DC load.

Definition

Use should include a comparison of components needed based on load type.

Process/Skill Questions

- How does a system configuration change when the load is AC vs. DC?
- How does one determine what size load a given array can power?
- Where is AC primarily used? DC?
- What are the advantages and disadvantages to AC and DC?

Common Career Technical Core

ST-SM1
Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.
ST2

Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 93

Calculate the system cost and payback period for a solar PV installation.

Definition

Calculation should include

- any state, local, or federal rebates
- loans
- tax credits
- carbon offsets
- savings from an electric bill
- rising cost of energy
- renewable energy credits.

Process/Skill Questions

- What are two reliable web sources for calculating payback for a given PV system?
- What are the costs to a complete 6-kilowatt PV system, including installation expenses?
- What are the current discounts and refunds available for PV installations?
- What are the current ways the PV owner can earn money from the renewable energy production?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

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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Task Number 94

Explain local solar power regulations and legislation.

Definition

Explanation should include the process for applying for permits and the fees involved.

Process/Skill Questions

- What are the current legal issues involving residential PV installations?
- Where can one find the regulations that govern PV installations?
- What are RECs?
- How does net-metering affect PV owners' costs and savings?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
ST4
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

ITEEA National Standards

16. Energy and Power Technologies

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

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Task Number 95

Complete a site analysis of various locations for PV installations.

Definition

Completion should involve

- finding true south
- considering future vegetation changes
- locating property boundaries
- determining roof condition and material
- reviewing ordinances and building codes.

Process/Skill Questions

- What is a solar pathfinder?
- What is irradiance?
- What is the difference between true south and magnetic south?
- What period of time must be considered when analyzing a potential site?
- How does time of year affect solar exposure?
- How many daily hours of usable light are typical for this area?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

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Examining Wind Power

Task Number 96

Explain global wind patterns and their causes.

Definition

Explanation should include a definition of *wind* as movement of air masses/parcels due to differential heating of the earth's varied surface covered by the sun.

Process/Skill Questions

- Where does wind come from (i.e., what is its source)?
- How is wind generated?
- What is the Coriolis effect, and how does it affect global wind patterns?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 97

Create a map of local, national, and global wind patterns, noting areas where wind turbines are widely used.

Definition

Creation should include

- vectors to represent known wind patterns
- symbols to represent wind turbine installations
- proposed locations where wind turbines may be installed in the future.

Process/Skill Questions

- Why are winds prevalent in certain areas of the globe? Are there specific seasonal differences in winds?
- Why are certain areas of the globe suitable or unsuitable for wind development?
- Why have some countries installed wind turbines while others have not?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

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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Task Number 98

Explain the effect of ground surface features on wind speed.

Definition

Explanation should include

- a discussion of obstacles that impede winds
- the effects of areas that are largely without obstacles to wind
- the effect of elevation on wind speed.

Process/Skill Questions

- What variables affect wind speed?
- What happens when there are no obstacles to the prevailing winds?
- What affect does moving higher in the atmosphere have on prevailing winds?
- What is wind shear?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 99

Explain the advantages and disadvantages of wind-powered electrical systems.

Definition

Explanation should include discussion of

- variable wind speed in most areas of the country
- greenhouse gas release with burning fossil fuels to produce energy vs. the clean electrical production from wind turbines
- the CO_2 / greenhouse gases released as a result of initial wind turbine construction.

Process/Skill Questions

- What is the cost of wind power per kilowatt-hour?
- What is the cost of small wind vs. utility wind?
- What are the benefits of generating power from wind energy?
- How does the condition of the electrical grid affect the ability to produce wind power economically?
- How does the geographic concentration of the population correlate to the location of most of the wind farms in the United States?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 100

Describe Betz's law and the conservation of energy.

Definition

Description should include the

- limit (theoretical) that at optimum conditions, approximately 58 percent of the wind's energy can be converted to electrical energy as a result of aerodynamic drag, mechanical resistance, etc.
- fact that energy is neither created nor destroyed, only transferred among forms.

Process/Skill Questions

- What technologies could allow wind turbines to reach their maximum efficiency?
- What practical limits are there on the amount of power that can be derived from the wind due to the conversions that are necessary?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 101

Identify the issues facing the widespread adoption of utility-scale wind energy production.

Definition

Identification should include

- competition from fossil fuels currently relied on
- infrastructure that must be developed to harness wind power
- geographic availability of a wind resource near major population centers

- cost of developing offshore wind energy.

Process/Skill Questions

- Why isn't wind power a major energy source in Virginia?
- What are the energy sources currently relied on to power Virginia's homes and economy?
- How much does wind power cost per kilowatt-hour when compared to fossil-fuel energy sources?
- What additional costs are not considered in this comparison?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

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Installing Wind Power Systems

Task Number 102

Research the function of the basic components in a residential-scale wind power system.

Definition

Research should include

- foundation
- tower
- nacelle/generator/gearbox/inverter
- rotor blades attached to a hub.

Process/Skill Questions

- Why is a strong foundation required for a wind turbine installation?
- What effects does a tower for a wind turbine have on its operation?
- What parts may be included in the nacelle?
- What does an inverter do?
- Why is turbine blade design important?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 103

Explain the aerodynamic principles that affect wind turbine performance, specifically with regard to rotor blade design.

Definition

Explanation should include

- lift
- drag
- leading edge
- airfoil
- angle of attack.

Process/Skill Questions

- What is drag?
- How does leading edge design affect rotor performance?
- How does an airfoil turn energy from the wind into mechanical work?
- How does adjusting the angle of attack affect the efficiency of a wind turbine?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 104

Explain horizontal and vertical wind turbine design and the advantages and disadvantages of each.

Definition

Explanation should include

- horizontal wind turbine
- vertical wind turbine (sometimes called the egg-beater, or Savonious, turbine).

Process/Skill Questions

- Why are most wind turbines built today with a horizontal design?
- What effects does the orientation of a wind turbine have on its operation?
- What parts may be difficult to service in either a horizontal or vertical configuration?
- What are some of the advantages of vertical and horizontal wind turbines?
- What are some of the disadvantages of vertical and horizontal wind turbines?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

Task Number 105

Explain the three scales of wind turbines and the applications for each.

Definition

Explanation should include residential or small, community, and utility.

Process/Skill Questions

- What is the definition of a small wind turbine?
- What is the generator size range for a small wind turbine?
- What is the definition of a community-scale wind turbine?
- What is the generator size range for a community-scale wind turbine?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 106

Describe the different types of materials that are used in wind turbine construction.

Definition

Description should include

- steel
- aluminum
- carbon fiber
- fiberglass
- other composites
- concrete.

Process/Skill Questions

- What parts of a wind turbine should be made of light materials?
- What parts of a wind turbine should be made of heavy materials?
- What parts of a wind turbine should be made of composite materials?
- Which materials would not be appropriate to use in the various parts of a wind turbine?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 107

Compare various wind turbine designs for their capabilities in generating electricity.

Definition

Comparison should include the differences between horizontal- and vertical-axis turbines with regard to

- efficiency
- power
- kilowatt
- energy/kWh or Joules.

Process/Skill Questions

- What environmental conditions could challenge the safe operation of wind turbines?
- What is efficiency, and how can it be improved or optimized?
- What is power?
- How is power measured in wind turbine design?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 108

Explain the various methods wind turbines employ to control wind speeds.

Definition

Explanation should include

- dynamic braking
- feathering of blades
- wind speed monitoring anemometer
- data acquisition
- electronic braking.

Process/Skill Questions

- What is dynamic braking?
- What is electronic braking?
- What is feathering of blades on a wind turbine, and when should it be performed?
- What is an anemometer?
- Why is data acquisition important on residential- to utility-scale wind turbines?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 109

Recommend the appropriate wind power system design (e.g., stand-alone, grid-tied, hybrid) for a customer's needs.

Definition

Recommendation should include

- electric grid
- battery bank
- inverter
- charge controller.

Process/Skill Questions

- What is the electric grid?
- How is a battery bank used to store electrical power generated from the wind?
- What is an inverter?
- Why might a designer specify a hybrid design for a wind turbine at a particular site?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

ITEEA National Standards

16. Energy and Power Technologies

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

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Task Number 110

Complete a site analysis for a potential wind power system.

Definition

Completion should include

- wind speed monitoring
- wind direction monitoring
- wind vane (i.e., weathervane)
- anemometer
- data acquisition
- sonic detection and ranging (SODAR)
- light detection and ranging (LIDAR).

Process/Skill Questions

- Why should sites be monitored prior to the installation of a wind turbine?
- Why should one measure the wind speed and direction of the wind?
- Why should one measure the wind speed and direction at multiple heights and in two directions at each height?
- What is an appropriate amount of time to measure the wind?
- What is an anemometer?
- Why is data acquisition important on residential- to utility-scale wind turbines?
- What is a SODAR, and what are the advantages and disadvantages of using it over a traditional anemometer and wind vane?
- What is a LIDAR, and what are the advantages and disadvantages of using it over a traditional anemometer and wind vane?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 111

Demonstrate the mounting of a model wind turbine system.

Definition

Demonstration should include

- nacelle
- tower
- rotor blades attached to a hub.

Process/Skill Questions

- What are the parts included in the nacelle of a particular type of wind turbine?
- What are the advantages and disadvantages of using a gearbox?
- How are tower sections lifted into place and interconnected?
- What steps need to be performed in the blade assembly of a particular wind turbine?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 112

Analyze the basic operation and output of a wind turbine.

Definition

Analysis should include

- miles per hour/meters per second
- resource planning model (RPM)
- voltage
- current
- power
- heading/prevailing wind.

Process/Skill Questions

- What is the conversion between miles per hour and meters per second?
- What is voltage, and how is it measured?
- What is current, and how is it measured?
- What is power, and how is it measured?
- What is wind speed, and how is it measured?
- How is wind direction measured?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 113

Observe the operation of a wind turbine connected to a DC load.

Definition

Observation should include

- DC
- load
- heat
- energy.

Process/Skill Questions

- What is DC?
- What is a load, and how is it measured?
- What is heat, and how is it measured?
- What is energy, and how is it measured?
- Why is measuring time important when measuring energy?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 114

Correlate wind power, speed, and electrical output of a wind turbine system.

Definition

Correlation should include

- wind power
- wind speed
- energy
- capacity factor
- power curve
- power equation.

Process/Skill Questions

- What is the practical limit of how much of the wind's energy can be captured?
- How does wind speed correlate to the electrical output of a wind turbine?
- How can one use the manufacturer's power curve to determine the potential power output of a wind turbine?
- What is the capacity factor? What is the realistic range of capacity factors for utility-scale wind turbines?
- What is the power equation?
- What variables are needed to calculate potential power from a wind turbine?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
ST2
Use technology to acquire, manipulate, analyze and report data.

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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Task Number 115

Locate wind turbine regulations and legislation.

Definition

Location should include

- code
- building permit office
- easement.

Process/Skill Questions

- What is building code, and who is responsible for it?
- Where is the building permit office in the local town or city?
- What is an easement, and how might one affect the installation of a wind turbine?

Common Career Technical Core

ST4
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

ITEEA National Standards

16. Energy and Power Technologies

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

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Task Number 116

Explain the factors to consider when siting a utility-scale wind farm.

Definition

Explanation should include

- wind resource
- proximity to a grid connection
- public acceptance
- wildlife effect
- noise/flicker effect

- local zoning and permitting
- wind farm layout.

Process/Skill Questions

- What are some environmental concerns regarding wind turbines?
- What is NIMBY, and how does it apply to siting a wind farm?
- What is the flicker effect, and how does it affect humans?
- How does one measure decibels? How loud is too loud?
- What is a zoning ordinance, and what are some of the common features discussed in a wind ordinance?
- What are the wake and park effects, and how do they affect wind farm layout?

ITEEA National Standards

16. Energy and Power Technologies

Examining Biomass and Biofuels

Task Number 117

Explain the difference between biomass and biofuels.

Definition

Explanation should include definitions of *biomass* (living) and *biofuel* (chemically converted biomass).

Process/Skill Questions

- What are pros and cons of biomass and biofuel?
- Which is more environmentally and economically sustainable, biomass or biofuel? What are the advantages and disadvantages of using biomass as a fuel source?
- What are various sources of biomass, and what potential problems could occur when they are harvested in large quantities?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 118

Create a model of the carbon cycle.

Definition

Creation should produce a virtual or physical model that includes the processes of

- sun and photosynthesis
- animal and plant respiration
- ocean uptake

Process/Skill Questions

- Where is excess atmospheric carbon generally stored?
- What is excess carbon doing to ocean ecosystems?
- What is the primary cause of the dramatic increase in CO_2 in the atmosphere?

Common Career Technical Core

ST-SM1
Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.

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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Task Number 119

Describe the carbon cycle's relationship to greenhouse gas levels in the atmosphere.

Definition

Description should include the carbon cycle's effect on greenhouse gas levels through

- carbon release from burning fossil fuels and biofuels
- deforestation
- agriculture.

Process/Skill Questions

- How has increased CO_2 in the atmosphere affected temperatures in various locations around the planet?
- How is carbon released from soil during traditional farming methods?
- What is the potential for various carbon capture models?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

5. The Effects of Technology on the Environment

Task Number 120

Explain how biomass is converted into usable energy.

Definition

Explanation should include how animal waste and plant material are converted into usable energy using processes such as

- digestion or decomposition
- extraction
- fermentation
- direct burning
- pyrolysis (heating in the absence of oxygen)

Process/Skill Questions

- What technologies are associated with the processes?
- Which use of biomass has the most potential to curb global climate change?
- How does using animal byproducts help solve other environmental effects from excess animal waste?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Exploring Energy Use in Transportation

Task Number 121

Explain fossil fuels' role in the global economy.

Definition

Explanation should include that a petroleum-based, intermodal transportation system is the primary energy source used to move people and goods around the globe.

Process/Skill Questions

- What is the transportation footprint of a T-shirt manufactured in China and sold in the local community?
- What is embodied energy?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
ST4
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

ITEEA National Standards

16. Energy and Power Technologies

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

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Task Number 122

Identify alternatives to the current fossil-fuel based transportation system.

Definition

Identification should include alternatives such as

- electric vehicles (EVs)
- hydrogen-powered vehicles
- alternative-fuel vehicles
- mass transit
- carpooling
- car and bike sharing
- telecommuting.

Process/Skill Questions

- What are some positive effects of mass transit?
- What method of transportation is most cost effective to the traveler traveling from Richmond to Washington, D.C.?

Common Career Technical Core

ST4
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 123

Research how freight is moved and the alternatives that will reduce this sector's demand for fossil fuels.

Definition

Research should include

- the amount of freight that is moved by the various modes of transportation (e.g., air, barge, shipping, truck, rail)
- localized economies
- alternative processes (e.g., liquefied natural gas).

Process/Skill Questions

- How is most freight transported in the United States?
- How could fuel usage to transport freight be reduced?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

18. Transportation Technologies

Task Number 124

Create a timeline of the history of transportation.

Definition

Timeline should include

- steam power
- gasoline engines
- hybrids
- electric vehicles.

Process/Skill Questions

- What are some limitations of steam-powered transportation?
- What are some pros and cons of vehicles powered by gasoline engines compared to electric vehicles?

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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Task Number 125

Explain the advantages and disadvantages associated with EVs.

Definition

Explanation should include

- advantages
    - decreased carbon emissions
    - integration with smart grid
- disadvantages
    - infrastructure
    - cost

- battery technologies
- maintenance.

Process/Skill Questions

- What are some positive outcomes of EVs?
- What is the total cost of owning and operating an EV for 10 years compared to a gasoline-fueled car of similar size and power?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

5. The Effects of Technology on the Environment

Task Number 126

Compare the various battery technologies used in the EV industry.

Definition

Comparison should include

- lead acid
- lithium ion
- nickel metal hydride (NiMH)
- zebra.

Process/Skill Questions

- Which battery technologies are showing the greatest promise in the automotive industry?
- What is a drawback of using a zebra battery?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

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

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Task Number 127

Describe how EVs work.

Definition

Description should include that electric vehicles

- are powered by a bank of batteries
- run on an electric motor
- do not use a transmission
- recharge by plugging into outlet.

Process/Skill Questions

- What are some differences between EVs and gasoline-powered vehicles?
- What are the dangers associated with EVs involved in car crashes both to the occupant and the emergency response personnel?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 128

Compare the types of hybrid and EVs.

Definition

Comparison should include the advantages and disadvantages of

- hybrid vehicles
  - at lower speeds, electric motor is used
  - at higher speeds (or greater demand), efficient gas motor is engaged
  - high-range vehicle
- EVs
  - electric motor used at all speeds
  - frequent charging required
  - low-range vehicle.

Process/Skill Questions

- What are some advantages of hybrid vehicles?
- Which vehicle type is most cost effective over a 10-year period?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

5. The Effects of Technology on the Environment

Task Number 129

Examine current mass transit systems in the United States.

Definition

Examination should include steps being taken to decrease mass transit systems' dependence on fossil fuels, such as

- priority of cargo over passengers
- electrification of buses
- infrastructure
- funding.

Process/Skill Questions

- What are the different types of mass transit?
- What is an affordable alternative to driving a personal vehicle from New York City to Sacramento?

Common Career Technical Core

ST4
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

ITEEA National Standards

16. Energy and Power Technologies

18. Transportation Technologies

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

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Task Number 130

Identify transportation options that may prove practical for mass transit.

Definition

Identification should include

- compressed natural gas for some depot-based vehicles (buses)
- biofuels (blended with diesel) in trains and trucks

- straight vegetable oils (SVO)
- planned residential development with connectivity to mass transit.

Process/Skill Questions

- What are some changes in mass transit that might be helpful to reducing use of fossil fuels?
- How is vegetable oil used in transportation?

Common Career Technical Core

ST4
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

ITEEA National Standards

16. Energy and Power Technologies

18. Transportation Technologies

Task Number 131

Explain how EVs could be used to supplement a smart grid with energy storage.

Definition

Explanation may include

- monetizing an EV while it's parked
- vehicle-to-grid
- bidirectional vehicle
- bidirectional charger.

Process/Skill Questions

- How could storing power in a vehicle benefit an owner?
- How can the power stored in EVs affect the power grid?

ITEEA National Standards

16. Energy and Power Technologies

18. Transportation Technologies

Understanding Hydropower

Task Number 132

Describe the role of hydropower in current energy production.

Definition

Description should include an analysis of the

- overall contribution of hydropower to the existing power supply
- available hydropower to different regions of the country.

Process/Skill Questions

- Will the United States expand hydropower in the forms of large dams?
- What are the current governmental policies and regulations regarding hydropower in the United States?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

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

Task Number 133

Explain how a river's head and water pressure are related.

Definition

Explanation should include

- defining *river head* and *water pressure*
- identifying how the river's head affects water pressure.

Process/Skill Questions

- What relationship does the size of a river's head have with the pressure of the water?
- What are the processes used to determine whether a river's head has sufficient flow to produce hydropower?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Task Number 134

Explain how water is distributed in different municipalities.

Definition

Explanation should include

- explaining how water is used and acquired in different countries around the world
- identifying the parts of a municipal water system.

Process/Skill Questions

- How is water treated and supplied to local areas?
- What are the differences in water supply systems in various regions of the United States and the world?

Common Career Technical Core

ST4
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 135

Identify the advantages and disadvantages of using water as a power source.

Definition

Identification should include the

- effects of drought on the power supply
- effects of a dam on the environment and surrounding areas
- costs associated with building and maintaining a hydropower plant and cost savings.

Process/Skill Questions

- Would using a hydropower plant in the local county be a reasonable endeavor?
- What are areas where hydropower would and would not be reasonable?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 136

Identify the steps necessary to perform a site assessment of a micro-hydro project.

Definition

Identification should include

- adequate head
- existing civil works
- proximity to a load
- minimal environmental disturbance
- clearly identified water rights.

Process/Skill Questions

- How could micro-hydro become a viable option in agriculture settings?
- What infrastructure is needed for a micro-hydro project?
- What environmental factors are considered in a site assessment?

Common Career Technical Core

ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

ITEEA National Standards

16. Energy and Power Technologies

5. The Effects of Technology on the Environment

Task Number 137

Calculate the power contained in a specific hydro source, given the flow and head of the stream or river.

Definition

Calculation should include

- load factor
- rated factor
- energy output.

Process/Skill Questions

- What is load factor, and how does its number affect the economic viability of a power source?
- How does one determine energy output?

Common Career Technical Core

ST-SM1
Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.
ST-SM2
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
ST2
Use technology to acquire, manipulate, analyze and report data.

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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Task Number 138

Identify the factors (other than available power) that must be considered when determining the viability of a specific micro-hydro site.

Definition

Identification should include

- water availability
- water rights
- local and regional policies and laws
- current infrastructure.

Process/Skill Questions

- Why is it important to identify water rights when determining the viability of a micro-hydro site?
- Where can one locate regional and local water policies and laws?
- What is a water authority, and how are they used?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 139

Create a model of a micro-hydropower system.

Definition

Creation of model should include

- water conveyance—channel, pipeline, or pressurized pipeline (penstock) that delivers the water
- turbine, pump, or waterwheel—transforms the energy of flowing water into rotational energy
- alternator or generator—transforms the rotational energy into electricity
- regulator—controls the generator wiring and delivers the electricity.

The model should also show both an AC and DC system.

Process/Skill Questions

- How does adding a generator affect flow and pressure of water?
- How does water conveyance affect the electrical output of a micro-hydropower system?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 140

Explain how the various micro-hydro turbines/generators work.

Definition

Explanation should include

- Pelton wheel
  - uses jet force to create energy
  - water is funneled into a pressurized pipeline with a narrow nozzle at one end
  - water sprays out of the nozzle in a jet, striking the double-cupped buckets attached to the wheel
  - the impact of the jet spray on the curved buckets creates a force that rotates the wheel at high efficiency rates of 70–90 percent
  - available in various sizes and operates best under low-flow and high-head conditions
- Turgo impulse wheel
  - upgraded version of the Pelton
  - uses the same jet spray concept, but the Turgo jet, which is half the size of the Pelton, is angled so that the spray hits three buckets at once--as a result, the Turgo wheel moves twice as fast
  - less bulky, needs few or no gears, and has a good reputation for trouble-free operations
  - can operate under low-flow conditions but requires a medium or high head
- Jack Rabbit turbine

- a drop-in-the-creek turbine that can generate power from a stream with as little as 13 inches of water and no head
- output is a maximum of 100 watts, so daily output averages 1.5–2.4 kilowatt-hours, depending on the site
- sometimes referred to as the Aquair UW Submersible Hydro Generator.

Process/Skill Questions

- Which type of generator is most applicable to agriculture usages?
- When is it appropriate to use each type of micro-hydro turbine/generator?
- Is one type of turbine/generator more efficient than the others?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 141

Explain the unique safety and maintenance issues involved in installing and operating a micro-hydropower system.

Definition

Explanation should include

- falling off the intake
- being struck by the rotating shaft
- electrocution.

Process/Skill Questions

- What training should someone have prior to installing and operating a micro-hydropower system?
- Where can someone get trained to install and operate a micro-hydropower system?
- What are the most common injuries that people face when working on micro-hydropower systems?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
ST3
Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.

ITEEA National Standards

16. Energy and Power Technologies

Examining Geothermal Energy

Task Number 142

Describe high- and low-temperature geothermal systems.

Definition

Description should include

- geo-exchange (geothermal loop) vs. deep-well design
- open loop vs. closed loop.

Process/Skill Questions

- What uses exist for high-temperature geothermal systems?
- Which geothermal system can produce utility-scale power?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 143

Describe how different geothermal energy systems are used to meet energy demands.

Definition

Description should include the following:

- Geo-exchange is used in residential and small-system designs.
- Deep-well is used for commercial and other large-scale systems.

Process/Skill Questions

- What is the cost for a geo-exchange system for a residential home?
- What tax credits are available for geo-exchange systems?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

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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Examining Hydrokinetic Energy

Task Number 144

Explain how tidal energy can be used to generate electricity.

Definition

Explanation should describe both the barrage and the tidal current or fencing systems.

Process/Skill Questions

- Hoes does a barrage tidal energy system work?
- What are the advantages to harnessing tidal energy?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 145

Investigate the latest technologies and system designs being used to harness tidal energy.

Definition

Investigation should include

- tidal fencing
- barrage (i.e., a floating dam that creates a tidal pool).

Process/Skill Questions

- What are ways energy may be captured from the ocean?
- How does tidal fencing help to harness energy from the ocean?

Common Career Technical Core

ST-SM4
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

ITEEA National Standards

16. Energy and Power Technologies

Task Number 146

Explain how wave and tidal energy can be used to generate electricity.

Definition

Explanation should include

- waves crossing the ocean can be predicted
- tides can be predicted
- use of buoys and turbines with the movement of the ocean can generate electricity.

Process/Skill Questions

- Why can the time a wave will arrive be predicted?
- Where can this technology best be used?

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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Task Number 147

Investigate the latest technologies and system designs being used to harness wave and tidal energy.

Definition

Investigation should include turbines designed to capture the movement of water oscillating water columns and emerging technologies.

Process/Skill Questions

- What is an oscillating water column?
- How is a tapered channel used to generate electricity?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 148

Experiment with capturing wave energy.

Definition

Experimentation should include using a wave generator in a tank and models of various wave energy capture devices.

Process/Skill Questions

- What is the most efficient device for capturing wave energy?

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	Explain the fundamental relationship between potential and kinetic energy.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 Science: PH.6
40	Demonstrate how batteries/cells function.	

41	Record battery charge and discharge rates in a data table.	
42	Use a multimeter to measure current, amps, voltage, and resistance in various direct current (DC) and alternating current (AC)energy systems.	Mathematics: A.4, AII.3 Science: PH.1
43	Create series and parallel circuits.	English: 10.5, 11.5, 12.5 Science: PH.11
44	Apply Ohm's law to determine the level of current flowing in a circuit.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 Mathematics: A.4, AII.3 Science: PH.11
45	Describe the uses of AC and DC.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 Science: PH.11
46	Explain the concept of phantom loads and their associated costs.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5
47	Estimate wattage.	
48	Identify fossil fuels and their uses.	English: 10.5, 11.5, 12.5 History and Social Science: VUS.8, WHII.8 Science: ES.6
49	Explain the process of global climate change.	English: 10.5, 11.5, 12.5 History and Social Science: VUS.14, WG.17, WHI.14
50	Create a video that explains the differences among renewable, inexhaustible, and non-renewable energy sources.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 Science: ES.6
51	Compare governmental policy and support for the fossil-fuel vs. the clean-energy economy.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.9, GOVT.15
52	Explain inefficiencies of modern energy systems.	English: 10.5, 11.5, 12.5
53	Describe various governmental initiatives and incentives to boost energy efficiency.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.9, GOVT.15
54	Explain the societal, environmental, and economic advantages of energy conservation.	English: 10.5, 11.5, 12.5 Science: PH.4

55	Describe how energy is used within various sectors of society.	English: 10.5, 11.5, 12.5 Science: PH.4
56	Conduct an energy audit of the local school building.	Science: PH.1, PH.2
57	Compute the energy savings that can be realized by modifying the building or energy-use patterns.	English: 10.5, 11.5, 12.5 Mathematics: A.4, AII.3 Science: PH.1, PH.2
58	Describe ways to test the integrity of a residential building's shell.	English: 10.5, 11.5, 12.5
59	Explain the recommended levels of insulation for local residential structures using the R-value system.	English: 10.5, 11.5, 12.5
60	Explain how windows and doors affect the energy efficiency of a home.	English: 10.5, 11.5, 12.5
61	Describe various water heating systems used in residential buildings and the advantages and disadvantages of each.	English: 10.5, 11.5, 12.5
62	Explain the theory of a hydrogen economy.	English: 10.3, 11.3, 12.3
63	Explain covalent bonding and its association with fuel cell technology.	English: 10.5, 11.5, 12.5 Science: CH.3
64	Explain the advantages and disadvantages of various methods of producing and transporting hydrogen.	English: 10.5, 11.5, 12.5
65	Explain the infrastructure challenges to fuel cells becoming a widely adopted technology.	English: 10.5, 11.5, 12.5
66	Demonstrate the operation of a hydrogen fuel cell.	
67	Define *fuel cell stack.*	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5
68	Diagram the connection of fuel cell stacks to produce various amounts of power at specific voltages.	Science: PH.7
69	Identify the various types of fuel cells.	English: 10.5, 11.5, 12.5
70	Compare PEM fuel cell and internal combustion engine (ICE) efficiencies.	English: 10.5, 11.5, 12.5 Mathematics: A.9, AFDA.8, AII.9, PS.1*, PS.17, PS.2*, PS.3*, PS.4*
71	Identify the components of a complete PEM fuel cell system.	English: 10.5, 11.5, 12.5
72	Compare the three major categories of fuel cell systems: stationary fuel cells,	English: 10.5, 11.5, 12.5

	fuel cell vehicles, and portable fuel cells.	
73	Research whether fuel cell technology is a realistic alternative to fossil fuels.	English: 10.8, 11.8, 12.8 History and Social Science: GOVT.9, GOVT.15, WG.2, WG.3, WG.4
74	Explain the differences between passive and active solar systems.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5
75	Design examples of daylighting systems.	
76	Explain the relationship of thermal mass to the storage of heat energy.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 Science: PH.7
77	Calculate the thermal storage capacity of various building materials.	Mathematics: A.4, AII.3 Science: CH.5
78	Explain direct, indirect, and isolated solar gain in passive solar power systems in buildings.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5
79	Describe the advantages and disadvantages of various solar thermal-heating systems.	English: 10.5, 11.5, 12.5
80	Complete a needs assessment, system sizing, and selection process for a residential solar thermal system.	
81	Describe the use of passive solar cooling systems in residential buildings.	English: 10.5, 11.5, 12.5
82	Explain the underlying principles of photovoltaic systems (PV) and factors that affect system efficiency.	English: 10.5, 11.5, 12.5 Science: PH.9
83	Describe advantages and disadvantages of various PV system configurations.	English: 10.5, 11.5, 12.5 Science: PH.9
84	Design a residential PV system to show the function of its components.	
85	Explain the functions of the major PV system components in residential structures.	English: 10.5, 11.5, 12.5
86	Explain issues related to the mounting of PV systems on a variety of structures.	English: 10.5, 11.5, 12.5
87	Assemble a model of a PV array.	
88	Measure PV array energy output under various conditions.	Science: PH.1
89	Create a model vehicle powered by solar energy.	

90	Present solar panel specifications, benefits to type of panel chosen, costs, and benefits for a variety of system designs.	English: 10.1, 11.1, 12.1
91	Connect a PV array to storage batteries.	Science: PH.11
92	Use a PV array to supply an AC load and a DC load.	Science: PH.11
93	Calculate the system cost and payback period for a solar PV installation.	Mathematics: A.4, AII.3
94	Explain local solar power regulations and legislation.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.9, GOVT.15
95	Complete a site analysis of various locations for PV installations.	
96	Explain global wind patterns and their causes.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 History and Social Science: WG.2 Science: ES.11
97	Create a map of local, national, and global wind patterns, noting areas where wind turbines are widely used.	History and Social Science: WG.1, WG.2, WG.3 Mathematics: MA.7
98	Explain the effect of ground surface features on wind speed.	English: 10.5, 11.5, 12.5 History and Social Science: WG.1, WG.2, WG.3
99	Explain the advantages and disadvantages of wind-powered electrical systems.	English: 10.5, 11.5, 12.5
100	Describe Betz's law and the conservation of energy.	English: 10.5, 11.5, 12.5 Mathematics: AII.3, AII.7, MA.4, MA.5
101	Identify the issues facing the widespread adoption of utility-scale wind energy production.	English: 10.5, 11.5, 12.5
102	Research the function of the basic components in a residential-scale wind power system.	English: 10.8, 11.8, 12.8 Science: PH.4
103	Explain the aerodynamic principles that affect wind turbine performance, specifically with regard to rotor blade design.	English: 10.5, 11.5, 12.5 Science: PH.4

104	Explain horizontal and vertical wind turbine design and the advantages and disadvantages of each.	English: 10.5, 11.5, 12.5
105	Explain the three scales of wind turbines and the applications for each.	English: 10.5, 11.1, 12.1
106	Describe the different types of materials that are used in wind turbine construction.	English: 10.5, 11.5, 12.5
107	Compare various wind turbine designs for their capabilities in generating electricity.	English: 10.5, 11.5, 12.5
108	Explain the various methods wind turbines employ to control wind speeds.	English: 10.5, 11.5, 12.5
109	Recommend the appropriate wind power system design (e.g., stand-alone, grid-tied, hybrid) for a customer's needs.	
110	Complete a site analysis for a potential wind power system.	History and Social Science: WG.1, WG.2, WG.3
111	Demonstrate the mounting of a model wind turbine system.	
112	Analyze the basic operation and output of a wind turbine.	English: 10.5, 11.5, 12.5 Science: PH.11
113	Observe the operation of a wind turbine connected to a DC load.	Science: PH.11
114	Correlate wind power, speed, and electrical output of a wind turbine system.	Mathematics: AII.3, AII.6, AII.7, MA.3, MA.4 Science: PH.11
115	Locate wind turbine regulations and legislation.	History and Social Science: GOVT.9, GOVT.15, WG.1, WG.2, WG.3
116	Explain the factors to consider when siting a utility-scale wind farm.	English: 10.5, 11.5, 12.5
117	Explain the difference between biomass and biofuels.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5
118	Create a model of the carbon cycle.	
119	Describe the carbon cycle's relationship to greenhouse gas levels in the atmosphere.	English: 10.5, 11.5, 12.5
120	Explain how biomass is converted into usable energy.	English: 10.5, 11.5, 12.5
121	Explain fossil fuels' role in the global economy.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.9, GOVT.15, WG.2, WG.3, WG.4, WG.16, WG.17, WG.18

122	Identify alternatives to the current fossil-fuel based transportation system.	English: 10.5, 11.5, 12.5 Science: PH.4
123	Research how freight is moved and the alternatives that will reduce this sector's demand for fossil fuels.	English: 10.8, 11.8, 12.8
124	Create a timeline of the history of transportation.	English: 10.8, 11.8, 12.8 History and Social Science: VUS.6, VUS.8, VUS.10, VUS.13, VUS.14 Science: PH.4
125	Explain the advantages and disadvantages associated with EVs.	English: 10.5, 11.5, 12.5
126	Compare the various battery technologies used in the EV industry.	English: 10.5, 11.5, 12.5
127	Describe how EVs work.	English: 10.5, 11.5, 12.5
128	Compare the types of hybrid and EVs.	English: 10.5, 11.5, 12.5
129	Examine current mass transit systems in the United States.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.9, GOVT.15, VUS.13, VUS.14, WHII.13, WHII.14
130	Identify transportation options that may prove practical for mass transit.	English: 10.5, 11.5, 12.5
131	Explain how EVs could be used to supplement a smart grid with energy storage.	English: 10.5, 11.5, 12.5
132	Describe the role of hydropower in current energy production.	English: 10.5, 11.5, 12.5 Science: PH.4
133	Explain how a river's head and water pressure are related.	English: 10.3, 10.5, 11.5, 12.5
134	Explain how water is distributed in different municipalities.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.15, WG.3, WG.4, WG.5, WG.6, WG.7, WG.8, WG.9, WG.10, WG.11, WG.12, WG.13, WG.14, WG.15, WG.16, WG.17, WG.18
135	Identify the advantages and disadvantages of using water as a power source.	English: 10.5, 11.5, 12.5
136	Identify the steps necessary to perform a site assessment of a micro-hydro project.	English: 10.5, 11.5, 12.5

137	Calculate the power contained in a specific hydro source, given the flow and head of the stream or river.	Mathematics: A.4, AII.3 Science: PH.4, PH.11
138	Identify the factors (other than available power) that must be considered when determining the viability of a specific micro-hydro site.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.15, WG.17, WG.18
139	Create a model of a micro-hydropower system.	Science: PH.1, PH.4
140	Explain how the various micro-hydro turbines/generators work.	English: 10.5, 11.5, 12.5
141	Explain the unique safety and maintenance issues involved in installing and operating a micro-hydropower system.	English: 10.5, 11.5, 12.5
142	Describe high- and low-temperature geothermal systems.	English: 10.5, 11.5, 12.5
143	Describe how different geothermal energy systems are used to meet energy demands.	English: 10.5, 11.5, 12.5
144	Explain how tidal energy can be used to generate electricity.	English: 10.5, 11.5, 12.5
145	Investigate the latest technologies and system designs being used to harness tidal energy.	English: 10.5, 11.5, 12.5
146	Explain how wave and tidal energy can be used to generate electricity.	English: 10.5, 11.5, 12.5
147	Investigate the latest technologies and system designs being used to harness wave and tidal energy.	English: 10.5, 11.5, 12.5
148	Experiment with capturing wave energy.	

Green Building Infusion Units

The Green Building Infusion Unit (GBIU) was designed to encourage teachers to infuse instructional units on green building knowledge and skills into designated CTE courses. The infusion unit is not mandatory, and, as such, the tasks/competencies are marked as “optional,” to be taught at the instructor’s discretion.

Entrepreneurship Infusion Units

Entrepreneurship Infusion Units may be used to help students achieve additional, focused competencies and enhance the validated tasks/competencies related to identifying and starting a

new business venture. Because the unit is a complement to certain designated courses and is not mandatory, all tasks/competencies are marked “optional.”

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- College and Work Readiness Assessment (CWRA+)
- 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.*

- Energy and Power (8448/36 weeks)
- Power and Transportation (8445/36 weeks)
- Sustainability and Renewable Technologies (8414/36 weeks)

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Chemical Engineer** **Civil Engineer** **Civil Engineering Technician** **Electrical Engineer** **Electrical Engineering Technician** **Electro-Mechanical Technician** **Engineer** **Engineering Manager** **Engineering Technician** **Environmental Engineer** **Industrial Engineer** **Industrial Engineering Technician** **Manufacturing Systems Engineer** **Mechanical Engineer** **Mechanical Engineering Technician** **Nuclear Engineer** **Petroleum Engineer** **Power Systems Engineer**
Science and Mathematics	**Atmospheric Scientist** **Botanist** **Ecologist** **Environmental Scientist** **Geoscientist** **Hydrologist**