Energy and Power

8448/36 weeks

8495/18 weeks

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Acknowledgments

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Correlations to the Virginia Standards of Learning were reviewed and updated by the following:

- Leslie R. Bowers, English Teacher (ret.), Newport News Public Schools
In this course, students analyze energy sources and explore the generation, transmission, and distribution of electricity using the Energy Industry Fundamentals modules from the Center for Energy Workforce Development (CEWD). The course provides math, science, and technical-writing skills through hands-on application. Students have an opportunity to take the Energy Industry Fundamentals Certificate Assessment.

### Task Essentials Table

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

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<thead>
<tr>
<th>Task Number</th>
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**Exploring the History of the Energy Industry**

39 🇺🇸 🇺🇸 Develop a timeline of energy innovation throughout history.

40 🇺🇸 🇺🇸 Discuss the history of energy as it pertains to mankind’s evolution to modern day sources.

41 🇺🇸 🇺🇸 Discuss the United States’ history of energy as it relates to modern day sources.

42 🇺🇸 🇺🇸 Research the processes of regulatory compliance.

**Introducing Energy**
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<th><strong>Define energy.</strong></th>
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<td>Describe types of energy and their uses.</td>
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<td>Describe the flow of energy from source to consumer.</td>
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<td>Demonstrate the use of tools and procedures common to jobs in energy industries.</td>
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<td>Demonstrate the use of instruments to measure units.</td>
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<td>Convert units of measure.</td>
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<td>49</td>
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<td>Analyze renewable and non-renewable sources of energy.</td>
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<tr>
<td>50</td>
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<td>Explain energy conversion.</td>
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### Introducing Safety and Regulations in Energy and Power

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<th>Explain the purpose of energy regulation.</th>
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<td>Identify the agencies involved in energy regulation.</td>
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<td>52</td>
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<td>Comply with federal, state, and local safety requirements.</td>
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<td>Explain safe working practices around electrical hazards.</td>
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<td>Identify emergency first-aid procedures.</td>
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<td>Inspect course-specific hand and power tools to visually identify defects.</td>
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<td>Demonstrate lifting and carrying techniques.</td>
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<td>Report personal injuries and environmental and equipment safety violations to the appropriate authority.</td>
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<td>Earn the OSHA 10 card.</td>
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<td>Pass a safety exam for lab/site safety and the use of tools and equipment, if applicable.</td>
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<td>60</td>
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<td>Identify personal protective equipment (PPE) requirements.</td>
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<td>Demonstrate the use of PPE common in electric power distribution.</td>
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<td>Maintain a safe working environment.</td>
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<td>Apply safety guidelines in appropriate circumstances.</td>
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<td>64</td>
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<td>Explain safety issues related to natural gas distribution.</td>
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### Exploring Sources of Energy

<table>
<thead>
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<th></th>
<th>Describe the procurement and reclamation processes (for each source of energy).</th>
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<td></td>
<td>Analyze continuous supply and intermittent supply.</td>
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<td>67</td>
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<td>Explain how oil was created and list its advantages and disadvantages.</td>
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<td>69</td>
<td>Explain how coal was created and list its advantages and disadvantages.</td>
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<td>70</td>
<td>Explain how uranium is created and list its advantages and disadvantages.</td>
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<tr>
<td>71</td>
<td>Describe byproduct management associated with the use of each type of energy.</td>
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<tr>
<td>72</td>
<td>Explore advantages and disadvantages of hydroelectric power.</td>
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<tr>
<td>73</td>
<td>Describe effects on solar photovoltaic performance.</td>
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<td>Generating Electricity</td>
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<td>75</td>
<td>Describe the conversion of energy sources (all sources) to electricity.</td>
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<td>Describe electric power generation equipment and systems.</td>
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<td>Transmitting Electricity</td>
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<td>78</td>
<td>Describe the electric transmission network or grid.</td>
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<td>Distinguish among the various lines used for transmission typical to Virginia.</td>
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<td>80</td>
<td>Analyze schemes for transmission and grid protection and management.</td>
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<td>81</td>
<td>Describe the transmission of natural gas.</td>
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<tr>
<td>82</td>
<td>Describe distribution of natural gas.</td>
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<tr>
<td>83</td>
<td>Analyze schemes for protection and management of pipelines.</td>
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<td>84</td>
<td>Describe pipes and pressure used in the transmission of natural gas.</td>
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<td>85</td>
<td>Analyze schemes for protection and management of natural gas distribution systems.</td>
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<tr>
<td>86</td>
<td>Explore Energy Consumption</td>
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<td>87</td>
<td>Describe the different physical units in which energy sources are measured.</td>
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<td>88</td>
<td>Explain how different energy sources are compared to each other in one common unit.</td>
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<tr>
<td>89</td>
<td>Compare the percentage of each energy source used in the United States over a period of time.</td>
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<tr>
<td>90</td>
<td>Explain different end-user sectors and the percentage of energy used by each.</td>
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</table>
Exploring Demand-Side Management and Energy Efficiency

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- Describe the sectors that comprise energy demand.
- Define energy demand.
- Investigate energy demand in a sector.
- Define energy efficiency.
- Keep a personal energy log.
- Identify the components of energy demand.

Preparing for Careers in the Energy Industry

<table>
<thead>
<tr>
<th>Task</th>
<th>Essential</th>
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- Examine jobs related to energy.
- Participate in a mock interview.
- Prepare a résumé or portfolio.

Legend: ✔️Essential ☐Non-essential ☐Omitted

Curriculum Framework

Exploring the History of the Energy Industry

Task Number 39

Develop a timeline of energy innovation throughout history.

Definition

Development should include:

- examples of energy conversion throughout history
- examples of energy development within the last century
- examples of energy innovation.

Process/Skill Questions

- What is meant by the phrase, “Necessity is the mother of invention”? How does this apply to energy innovation throughout history?
- What are some examples of how technology has evolved to enable energy conversion?

ITEEA National Standards

- ITEEA STEL 6

TSA Standards

- Technology Bowl

Task Number 40
Discuss the history of energy as it pertains to mankind’s evolution to modern day sources.

Definition
Discussion should include the
- discovery of fire
- use of wind and solar during the Renaissance and Medieval ages
- use of the steam engine sparking the Industrial Revolution
- use of coal and fossil fuels for transportation.

Process/Skill Questions
- How was the domestication of horses expanded to not only perform labor for farming tasks, but also for transportation?
- When did coal and other fossil fuels begin to power various forms of transportation?
- What other forms of alternative energy have been used in an effort to curb the use of fossil fuels?

ITEEA National Standards
- STEL 6, 5

TSA Standards
- Technology Bowl
- Children’s Stories
- Technology Bowl

Task Number 41
Discuss the United States’ history of energy as it relates to modern day sources.

Definition
Discussion should include
- the first coal deposits in the United States
- the steam engine as an energy source
- oil and gasoline usage in transportation
- creation of the Federal Power Commission (FPC)
- the Atomic Energy Act of 1954
- the Energy Policy and Conservation Act of 1975
- the Nuclear Waste Policy Act of 1982
- the Clean Air Act Amendments of 1990
- the Paris Agreement of 2016.

Process/Skill Questions
- What versatile source of energy was used for construction in colonial days, that was also used as a weapon in times of emergency?
- At what time did coal replace wood to power locomotive engines?
- What powered lamps before the widespread use of electricity?
- What U.S. Bureau was created in response to the underground explosion at the Monongah Mine in West Virginia?
- What state has become the world’s largest geothermal provider through its acquisition of Magma Power?
ITEEA National Standards
- STEL 6

**Task Number 42**

**Research the processes of regulatory compliance.**

**Definition**
Research could include
- origin of regulations (e.g., advocacy, incident)
- applicability of regulations to a specific situation or entity
- local and state permitting
- compliance and reporting requirements
- enforcement of regulations.

**Process/Skill Questions**
- Why do various agencies overlap in their oversight of the energy sector?
- What happens when an entity is not in compliance with a regulation?
- What tools or strategies do facilities and/or organizations use to comply with regulations?
- How can regulation affect economic growth?
- How can an individual influence the regulatory process?

ITEEA National Standards
- STEL 3

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**Introducing Energy**

**Task Number 43**

**Define energy.**

**Definition**
Definition should include concepts including
- power derived from the use of thermal, mechanical, chemical, or radiant resources
- kinetic vs. potential energy
- units of measure (e.g., watt, volt, Roentgen equivalent man [rem], gallons per minute [gpm], ampere, radiation-absorbed dose [rad], British thermal unit [BTUs], calories, horsepower, pounds per square inch [PSI], torque, Fahrenheit, pounds per hour [lbs/hr]).

**Process/Skill Questions**
- What is the difference between power and energy?
- What are examples of energy transfer?
- What do force and distance mean in the formula for work?

ITEEA National Standards
- STEL 2
TSA Standards
• Technology Bowl

Task Number 44
Describe types of energy and their uses.

Definition
Description should include the use of the following types of energy to produce electricity:
• Thermal — internal energy of a system in thermodynamic equilibrium by virtue of its temperature used for such things as home heating, transportation, cooking, water heating, industrial production, boilers, nuclear medicine, x-rays
• Mechanical — energy associated with the motion and position of an object used for such things as transportation, power production, wind turbines, and steam turbines
• Chemical — batteries, fuel, food, used for such things as transportation, computers, phones
• Radiant — electromagnetic energy that travels in transverse waves used for heat, light, powers solar panels
• Electrical — energy made available by the flow of electric charge through a conductor used for such things as home appliances, street lights, athletic field lighting, theme parks, electric cars.

Process/Skill Questions
• What are some common applications of chemical energy?
• How is the type of energy to be used determined?
• How is electricity a result of thermal, mechanical, or chemical generation?
• What type of energy is used to power batteries? Why is that the best choice?
• What types of energy are used in the transportation industry?

ITEEA National Standards
• STEL 2

TSA Standards
• Technology Bowl

Task Number 45
Describe the flow of energy from source to consumer.

Definition
Description should include the following components:
• Source (fuels)
• Generation
• Transmission
• Distribution
• Consumer use
• How is energy modified as it flows from its source to the consumer?
• Why is it important for the consumer to be knowledgeable about the flow of energy?
• What are some local sources of energy? Where does your electricity come from?
Demonstrate the use of tools and procedures common to jobs in energy industries.

Demonstration should include basic hand tools (e.g., screwdriver, wrenches, wire strippers, wire cutters, crimpers), basic portable power tools (e.g., circular saw, drill), multimeters, and applications such as gauging, measuring, connecting, terminating, and grounding.

What are the consequences of not being able to use basic hand tools? When is a multimeter used? What does it measure? Why is it important to use specific tools for a specific job?

Demonstrate the use of instruments to measure units.

Demonstration should include collecting data (wattage, voltage, amperage, torque, temperature, resistance, pressure) with instruments that may include the following:

Multimeter (digital and analog), Ammeter, Voltmeter, Oscilloscope, Geiger counter, Dosimeter, Torque wrench, Pressure gauge, Control valve, Spring scale, Thermometer (e.g., red alcohol, mercury, laser, probe)

How is current flow verified? When should a torque wrench be used?
In what industry is a Geiger counter used? How is it different than a dosimeter?

**ITEEA National Standards**
- STEL 8, 3

**TSA Standards**
- Principles of Technology (Virginia only event)

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**Task Number 48**

**Convert units of measure.**

**Definition**
Converting should include the use of unit conversion charts and formulas (e.g., Watt’s law, Ohm’s law, ideal gas law) to convert
- metric to standard, vice versa
- scientific notation (e.g., kilo-, mega-, giga-, micro).

**Process/Skill Questions**
- Why is it important to know the difference between metric and standard measurement systems? What are the consequences of not understanding the difference?
- How is scientific notation used in converting units of measure?

**ITEEA National Standards**
- STEL 3

**TSA Standards**
- Principles of Technology (Virginia only event)

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**Task Number 49**

**Analyze renewable and non-renewable sources of energy.**

**Definition**
Analysis should include the benefits and drawbacks of the following sources:
- Renewable energy and storage policy
  - Renewable portfolio standards (RPS)
  - solar
  - wind
  - biomass
  - ocean (including tidal, wave, current, thermal)
  - geothermal
  - hydroelectric
  - energy storage

**Process/Skill Questions**
- What is the difference between a renewable source of energy and a non-renewable source?
- What are advantages and disadvantages of renewable and nonrenewable sources?
- How do renewable and nonrenewable sources relate to sustainability?
Task Number 50

Explain energy conversion.

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

- transformation of energy from forms provided by nature to forms that can be used by humans (e.g., windmills, solar panels, hydroelectric plant)
- efficiency — loss of energy in conversion process (put in 100 percent, never get 100 percent out)
- kinetic energy vs. potential energy.

Process/Skill Questions
- What are some examples of energy conversion?
- How is efficiency calculated?
- What are some examples of losses in the energy conversion process? Why is energy always lost in the process?
- What factors could improve efficiency?

Introducing Safety and Regulations in Energy and Power

Task Number 51

Explain the purpose of energy regulation.

Definition
Explanation should include

- sustainability and efficiency
- health and safety
- environmental stewardship
- waste management
  - transportation
  - storage
  - wildlife protection
  - cultural and historic resources protection
- fair trade
• national security
• reliability
• security
• communications
• protection of intellectual property.

Process/Skill Questions
• Why is energy regulated?
• How does national security relate to energy?
• How does politics influence energy regulation?

ITEEA National Standards
• STEL 5

TSA Standards
• Technology Bowl

Task Number 52
Identify the agencies involved in energy regulation.

Definition
Identification should include
• localities
• state agencies
  o Virginia Department of Environmental Quality (DEQ), https://www.deq.virginia.gov/
  o Virginia Department of Transportation (VDOT), http://www.virginiadot.org/
  o Virginia Department of Health (VDH), https://www.vdh.virginia.gov/
• federal agencies
  o Rural Utilities Service (RUS), https://www.rd.usda.gov/about-rd/agencies/rural-utilities-service
  o Federal Communications Commission (FCC), https://www.fcc.gov/
  o Federal Aviation Administration (FAA), https://www.faa.gov/
  o FEMA, https://www.fema.gov/
  o U.S. Environmental Protection Agency (EPA), https://www.epa.gov/
  o U.S. Nuclear Regulatory Commission (NRC), https://www.nrc.gov/
  o Occupational Safety and Health Administration (OSHA), https://www.osha.gov/
  o Bureau of Ocean Energy Management (BOEM), https://www.boem.gov/
international
  - International Atomic Energy Agency (IAEA), https://www.iaea.org/

Process/Skill Questions
- How does agency leadership and funding affect regulation enforcement?
- What is the purpose and function of the Virginia SCC?
- What is the process by which a utility in Virginia gains approval to build a new power plant?

ITEEA National Standards
- STEL 5

TSA Standards
- Technology Bowl

Task Number 53
Comply with federal, state, and local safety requirements.
Definition
Compliance should include
- understanding the roles of the OSHA, VOSH, and the EPA
- identifying the OSHA Hazard Communication Standard (HCS)
- interpreting the information included on safety data sheets (SDS)
- describing the responsibilities of employers and employees under HCS.

Process/Skill Questions
- Where should hazardous materials be stored?
- What information can be found on an SDS?

ITEEA National Standards
- STEL 2

Task Number 54
Explain safe working practices around electrical hazards.
Definition
Explanation should include
- identifying equipment used to test electrical circuits
- describing safe working conditions (e.g., grounding, using ground-fault circuit interrupters [GFCIs] and cords, circuit breakers, power line safety)
- describing safe work habits.

Process/Skill Questions
- What is the definition of proximity work?
- What are safe working clearances, according to the National Electrical Code (NEC)?
- What are considered safe working conditions and safe working habits?
- What is the unseen hazard with electrical work?
ITEEA National Standards
- STEL 2

TSA Standards
- Principles of Technology (Virginia only event)

Task Number 55
Identify emergency first-aid procedures.

Definition
Identification should include standard first-aid procedures and school policies regarding incidents involving
- bodily fluids
- electrical injuries
- eye injuries
- falls
- burns.

Process/Skill Questions
- What steps should be followed in the event of an accident?
- Why is knowing cardiopulmonary resuscitation (CPR) important?
- Why is it important to be certified to administer first aid?
- What are the different classifications (degrees) of electrical burns?

Task Number 56
Inspect course-specific hand and power tools to visually identify defects.

Definition
Inspection of tools should include
- identifying components of machinery (e.g., guards, blades, moving parts, start/stop switches)
- identifying standard safety procedures (i.e., lab practices and manufacturer recommendations)
- observing a demonstration of the safe operation and use of each piece of machinery in the lab
- identifying tool defects.

Process/Skill Questions
- What should be done before using a power circular saw?
- Why should a power tool always be grounded?

ITEEA National Standards
- STEL 8
Task Number 57

Demonstrate lifting and carrying techniques.

Definition
Demonstration involves lifting and carrying materials and equipment and

- lifting with the legs
- keeping the back straight
- holding the load close to the body
- getting help, if necessary.

Process/Skill Questions
- What are common injuries associated with improper lifting techniques?
- What can one do to prevent injury?
- How does proper positioning affect proper technique?

Task Number 58

Report personal injuries and environmental and equipment safety violations to the appropriate authority.

Definition
Report should include

- identifying the violation
- documenting the date when the incident or behavior was observed
- submitting the report to the instructor, supervisor, or the local OSHA inspector.

Process/Skill Questions
- Why is it important to report injuries?
- What are common reporting procedures?
- What are the key components of a report?
- What ethical considerations might be involved when reporting coworkers?
- Why is it important to follow reporting procedures?
- What is liability?

Task Number 59

Earn the OSHA 10 card.

Definition
Earning an OSHA 10 card

- will recognize that one has acquired 10 hours of safety instruction
- will help teach national standards for personal safety within a lab environment
- will validate safety skills to the industry
- will help workers become more safety conscious and responsible.

Process/Skill Questions
- What are the benefits of earning the OSHA 10 card?
• What is OSHA and how are its standards validated?
• Why was OSHA established and how has it evolved?

Task Number 60
Pass a safety exam for lab/site safety and the use of tools and equipment, if applicable.

Definition
Passing should include use of an assessment that measures participation in safety training programs, including safety meetings, and demonstrating knowledge and skills gained from program topics (e.g., interpretation of SDS, use of tools and machines).

Process/Skill Questions
• How often should one participate in safety training programs? Why?
• How does insurance affect the requirement of continuous retraining for safety?
• What is workers' compensation? What is a safety committee and who are the members?
• What is the OSHA Voluntary Protection Programs (VPP) Star Program?

ITEEA National Standards
• STEL 8

Task Number 61
Identify personal protective equipment (PPE) requirements.

Definition
Identification could include procedures for inspecting, wearing, and removing
• eye protection
• a respirator
• a hard hat
• gloves
• a safety harness
• hearing protection
• safety shoes.

Identification should also include explaining when particular PPE is required.

Process/Skill Questions
• What are dangerous effects of sun exposure, and how can one significantly prevent these effects?
• Why is wearing jewelry prohibited while in the lab or on the jobsite?
• What is the appropriate dress code while handling hazardous chemicals in the lab?

ITEEA National Standards
• STEL 8

Task Number 62
Demonstrate the use of PPE common in electric power distribution.

Definition
Demonstration should include

- protective rubber gloves
- protective leather gloves
- protective rubber sleeves
- eye protection
- hard hat
- face mask, shields
- foot protection
- grounding probe.

Process/Skill Questions
- What is the purpose of using a grounding probe?
- What are the legal consequences of failure to wear PPE?
- What are different ratings for PPE?
- What are the different ratings for hearing protection?

Task Number 63
Maintain a safe working environment.

Definition
Maintaining safety should result in identifying potential hazards on a jobsite or in the lab, such as

- unstable or improperly erected scaffolding
- electrical hazards
- jobsite debris
- improperly stored materials
- air quality hazards.

When present, hazards must be remedied, in compliance with school and instructor guidelines.

Process/Skill Questions
- What are some examples of jobsite hazards?
- Why is it important to use good housekeeping standards on a jobsite?
- What is an ergonomics assessment?
- What is an industrial hygiene survey?
- Why is it important to store materials and tools in their proper places?

ITEEA National Standards
- STEL 2

Task Number 64
Apply safety guidelines in appropriate circumstances.

Definition
Application should include
  o personal protective equipment (PPE)
  o lockout/tagout procedures
  o guidelines relating to confined space
  o hearing protection
  o respiratory protection
  o work permits
  o guidelines relating to hazardous waste and materials
• manufacturer guidelines for maintenance and use of tools, shop equipment and equipment maintaining lab safety
• conduct testing, calibration, and measurement requirements
• American Society of Mechanical Engineers (ASME) codes, https://www.asme.org/codes-standards
• National Board of Boiler and Pressure Vessel Inspectors (NBBI) codes, https://www.nationalboard.org/

Process/Skill Questions

• What are some OSHA guidelines for safety?
• What safety guidance does ASME provide?
• What are the guidelines for mitigating employee fatigue in the DOT Fatigue Management Program?
• What is an Audiogram?

ITEEA National Standards

• STEL 2, 8

Task Number 65

Explain safety issues related to natural gas distribution.

Definition
Explanation should include
• airborne, soilborne, and waterborne hazards
• flammability
• pressure
• dew point
• respiratory issues
• pipeline integrity
• grounding.
Process/Skill Questions

• Why does natural gas have a "rotten egg" odor?
• What precautions should be taken before digging in one's yard?
• What should you do if you smell gas in a building?
• What is the difference between maximum operating pressure (MOP) and maximum allowable operating pressure (MAOP)?

ITEEA National Standards

• STEL 8

Exploring Sources of Energy

Task Number 66

Describe the procurement and reclamation processes (for each source of energy).

Definition

Description should include definitions of

• procurement—acquiring the source, processing/converting it so that it can be used, and transporting it to the end user (e.g., generation facility, industrial facility, home owner)
• reclamation—restoration of the affected environment after the resource is procured

and the specific applications of both as they relate to

• thermal energy (e.g., mining, drilling, hydraulic fracturing, water containment)
• mechanical energy (e.g., facility construction, generators, turbines, transmission, transportation)
• chemical energy (e.g., refining, processing, containment, combination, disposal).

Process/Skill Questions

• Why is it important for industry to restore affected environments after procurement?
• What is your local area’s permitting process?
• What are some issues related to fracking?

ITEEA National Standards

• STEL 8

Task Number 67

Analyze continuous supply and intermittent supply.

Definition

Analysis should address the concept that some sources (e.g., fossil, fuel, nuclear, biomass) provide a continuous supply where other sources (e.g., hydro, solar, wind, battery) provide supply intermittently.

Process/Skill Questions

• Why are wind and solar considered intermittent supplies of energy?
• What sources are considered continuous? What makes them continuous?
• What does off the grid mean? Is it possible to receive continuous energy supply off the grid?
• What can the consumer do to conserve energy? What can producers use to conserve energy?

ITEEA National Standards
• STEL 3

TSA Standards
• Technology Bowl

Task Number 68

Explain how oil was created and list its advantages and disadvantages.

Definition
Explanation should include that prehistoric microorganisms decomposed and collected in deposits. Some migrated upward as liquid until it reached impervious rock and formed oil deposits.

The advantages of oil include its use in
• heating
• transportation
• production of some plastics.

The disadvantages of oil include that
• air pollution (e.g., gases formed)
• limitation in supply
• environmental threat (e.g., oil spill, plastics break down into microscopic pieces).

Process/Skill Questions
• Where does the U.S. get its oil?
• What happens to oil after it leaves the well?
• How has oil become an environmental threat?

ITEEA National Standards
• STEL 3

TSA Standards
• Technology Bowl

Task Number 69

Explain how coal was created and list its advantages and disadvantages.

Definition
Explanation should include the concept that prehistoric organic material under high pressure and temperature mixed with minerals, which converted to coal deposits.
The advantage of coal is it can provide heat and thereby produce steam for electric power generation.

The disadvantages of coal include that

- it is non-renewable
- it is becoming harder to obtain
- its burning produces green-house gases.

Process/Skill Questions

- How did coal form?
- What are some disadvantages of coal?
- What effect does the burning of coal have on the environment?

ITEEA National Standards

- STEL 3

TSA Standards

- Technology Bowl

Task Number 70

Explain how uranium is created and list its advantages and disadvantages.

Definition

Explanation should include that uranium is a mineral deposited in ore that is mined from the ground. To use it in the form of nuclear fuel, it must be refined from the ore.

The advantage of uranium is that it does not produce pollution when used as a fuel.

The disadvantage of uranium is that spent uranium fuel is radioactive and must be stored in secure ways to prevent leakage of radioactivity.

Process/Skill Questions

- Where does the U.S. get most of its uranium?
- How is uranium used?
- What is a medical use of uranium?

ITEEA National Standards

- STEL 3

TSA Standards

- Technology Bowl

Task Number 71

Describe byproduct management associated with the use of each type of energy.

Definition

Description should include methods and issues related to

- thermal energy, such as
• filtration
• chemical treatment
• cooling tanks
• ventilation
• mechanical energy, such as
  • recycling
  • maintenance
  • replacement of parts
• chemical energy, such as
  • hazardous materials
  • disposal
  • containment
  • recycling.

Process/Skill Questions
• What are some means of nuclear waste disposal?
• What are some local resources for proper recycling and disposal?
• What are the consequences of failure to properly manage byproducts?

ITEEA National Standards
• STEL 3

TSA Standards
• Technology Bowl

Task Number 72
Explore advantages and disadvantages of hydroelectric power.

Definition
Exploration may include
• issues and risks associated with hydroelectric power
• water quality
  • oxygen levels
  • water flow
  • aerating turbine solutions
• fish population and migration
  • fish population allowed to migrate according to natural behavior
  • drop differences and bottom areas
  • water velocity
• technologies
  • helicoid penstocks
  • hydrosphere
  • air-water-gravity generator
  • hydrokinetic systems
  • vortex
  • sewer/wastewater pipe power
  • fish ladders.

Process/Skill Questions
• What are advantages of hydroelectric power?
• What are some effects on fish populations?
ITEEA National Standards
- STEL 3

TSA Standards
- Technology Bowl

Task Number 73
Describe effects on solar photovoltaic performance.

Definition
Description should include
- siting
- angles
- orientation
- geography
- shading
- solar map interpretation.

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

ITEEA National Standards
- STEL 8

TSA Standards
- Children’s Stories

Generating Electricity

Task Number 74
Describe the conversion of energy sources (all sources) to electricity.

Definition
Description should include the following processes:
- Thermal energy (e.g., steam) is converted to mechanical energy, which is converted to electrical energy.
- Mechanical energy (e.g., water wheel, wind mill) is converted to electrical energy.
- Chemical energy is converted directly to electrical energy.

Process/Skill Questions
- What are different ways of spinning a turbine?
- Why is water so important to energy production?
- How do thermal, mechanical, and chemical compare to each other in terms of overall efficiency?
Task Number 75
Describe electric power generation equipment and systems.

Definition
Description should include
- generators
- turbines
- batteries
- photovoltaic cells.

Process/Skill Questions
- What are the components of a generator and a turbine?
- What are the advantages and disadvantages of photovoltaic cells?
- What are different types of batteries? How efficient is each?
- How are power systems managed?

Transmitting Electricity

Task Number 76
Describe the electric transmission network or grid.

Definition
Description should include
- a definition of transmission—the movement of electricity over long distances via high voltage transmission lines (69-765 kv) from a power station to substations
- identification of basic symbols
- components of the transmission network or grid, such as
  - power station
  - step-up transformers
  - switchyard
  - towers
  - lines (overhead and underground)
  - transmission substation
  - step-down transformers
  - breakers/fuses.
Process/Skill Questions

- What is the role of each component in the transmission of electricity?
- What is the importance of step-up and step-down transformers in a grid/network?
- What are the pros and cons of overhead lines and underground lines?

ITEEA National Standards

- STEL 8

TSA Standards

- Technology Bowl
- Principles of Technology (Virginia only event)

Task Number 77

Distinguish among the various lines used for transmission typical to Virginia.

Definition

Distinction should include the following lines and their uses:
- 500-765 kv, used for bulk transmission (e.g., substation to substation)
- 115-230 kv, used for industrial applications (e.g., paper mill, data center, computer server farm)
- 69-115 kv, used for commercial and residential substations (e.g., shopping centers, neighborhoods).

Process/Skill Questions

- What are some resources for determining appropriate line size?
- What does the size of the transmission line have to do with the amount of energy being transferred?
- Why do industrial applications require larger lines than residential applications?

Task Number 78

Analyze schemes for transmission and grid protection and management.

Definition

Analysis should include the roles and/or uses of the following:
- Sectionalization, which is the use of protective relays to isolate faulted portions of the distribution grid
- Right-of-way management
- Blackout analysis
- Integration of cybersecurity
- Reliability and security organizations and regulatory bodies (e.g., North American Electric Reliability Corporation (NERC), SERC Reliability Corporation)
- Regional transmission organizations (e.g., PJM Interconnection)

Process/Skill Questions

- Why is right-of-way management important to the landowner and the consumer?
• Why are regional transmission organizations needed? What is their role in energy transmission?
• What is the purpose of a blackout analysis?
• What are some threats to the power grid? How can they be mitigated?

TSA Standards
• Cybersecurity

Task Number 79
Describe the transmission of natural gas.

Definition
Description should include
• definition of transmission—the movement of natural gas over long distances via pipelines
• identification of basic symbols
• components of transmission, such as
  o step-up compressors
  o pipelines
  o line pack
  o step-down compressors
  o breakers
  o processing facilities.

Process/Skill Questions
• What is line pack?
• What are the roles of a step-up compressor and a step-down compressor?
• How is natural gas refined before transmission to the consumer?

ITEEA National Standards
• STEL 8

TSA Standards
• Technology Bowl

Task Number 80
Describe distribution of natural gas.

Definition
Description should include components that make up the final steps in the delivery of natural gas to the consumer, such as
• pipelines
• tanks
• truck delivery.
• What are differences between delivery of gas in rural areas and delivery in urban areas?
• What are the benefits of propane tanks to the consumer and to the utility?

ITEEA National Standards
• STEL 8
TSA Standards
- Technology Bowl
- Principles of Technology (Virginia only event)

Task Number 81
Describe pipes and pressure used in the transmission of natural gas.
Definition
Description should include the materials (e.g., steel) used in and the varying diameters (from 6 to 48 inches) of pipes used to transmit natural gas and the role of pressure in transmission.
Process/Skill Questions
- How do the various materials used in pipes vary with regard to efficiency and with regard to maintenance?
- Where are the widest pipes used and the narrowest pipes used?

ITEEA National Standards
- STEL 3, 8

Task Number 82
Analyze schemes for protection and management of pipelines.
Definition
Analysis should include
- right-of-way management
- reliability and security organizations and regulatory bodies.
Process/Skill Questions
- What threats are there to the distribution of natural gas?
- How are pipelines maintained?

Distributing Electricity and Energy Sources
Task Number 83
Describe the electric distribution network.
Definition
Description should include
- a definition of distribution—the delivery of electricity via lines (e.g., primary voltages from 2400 v to 34,520 v; secondary voltages from 120 v to 480 v) from substations to consumers
• identification of basic symbols
• components of distribution, such as
  o substation (e.g., step-down transformers, switches, breakers, buss work)
  o voltage regulators
  o poles
  o distribution lines (e.g., overhead and underground)
  o protective devices (e.g., fuses, breakers, reclosers, cut-outs, grounding system)
  o services
  o meters.

Teacher resource:
What is a Metering System? Elexon Balancing and Settlement Code (BSC),
https://www.elexon.co.uk/knowledgebase/what-is-a-metering-system/

Process/Skill Questions
• Where might underground lines be used instead of overhead lines?
• What is the difference between a fuse and a breaker?
• How are electric meters used in billing for energy consumption?
• What is an electrical substation and its purpose?
• How can a one-line diagram identify the parts of a system?
• Why is it important to ground electrical current?

ITEEA National Standards
• STEL 2, 8

TSA Standards
• Technology Bowl
• Principles of Technology (Virginia only event)

Task Number 84
Analyze schemes for electric distribution system protection and management.

Definition
Analysis should include schemes such as
• right-of-way management
• systems operations and scheduled maintenance
• sectionalization
• rolling blackouts.

Process/Skill Questions
• Why are rolling blackouts used?
• What role does sectionalization play in protecting the distribution system?
• What are the components of systems operation?

Task Number 85
Analyze schemes for protection and management of natural gas distribution systems.
Task Number 86

Describe the different physical units in which energy sources are measured.

Definition
Description should include
- liquid fuels (i.e., gallons, barrels)
- gas fuels (i.e., cubic feet)
- coal (i.e., short tons)
- electricity (i.e., kilowatt hours).

Process/Skill Questions
- Why is it important to know the measurement units?
- How does one know which unit to use to measure which source?

ITEEA National Standards
- STEL 3

TSA Standards
- Technology Bowl

Task Number 87

Explain how different energy sources are compared to each other in one common unit.

Definition
Explanation should include the
- definition of British thermal units (BTU)
- conversion process.

Process/Skill Questions
- Why is it important to have a common measurement tool for comparison?
- What could happen if different measurement tools were used?
Task Number 88

Compare the percentage of each energy source used in the United States over a period of time.

Definition
Comparison should include graphs that have use and consumption for each energy resource.

Teacher resource:

Process/Skill Questions
- How have global trends affected the use of each energy source over the past century?
- What are some reactions to negative global trends?

Task Number 89

Explain different end-user sectors and the percentage of energy used by each.

Definition
Explanation should include end-user sectors (e.g., transportation, industrial) and how much energy each uses.

Process/Skill Questions
- How is this data used to reduce the total amount of energy used?
- What is done with the data compiled?

Exploring Demand-Side Management and Energy Efficiency

Task Number 90

Describe the sectors that comprise energy demand.

Definition
Description should include
- residential
- commercial
- industrial
- transportation
- other (e.g., military, community).

Teacher Resources:
- National Energy Education Development (NEED), https://www.need.org/
Process/Skill Questions

- What additional sectors may exist?
- What are examples of users across each of these sectors?
- What percentage of total national energy consumption does each sector represent?
- What non-electrical energy is part of the utility infrastructure?

ITEEA National Standards

- STEL 8

TSA Standards

- Technology Bowl

Task Number 91

Define energy demand.

Definition
Definition should include components such as

- consumers
- conservation and efficiency
- renewable energy
- diversity of energy sources
- environmental and economic effects and considerations
- innovation.

Process/Skill Questions

- What is the difference between conservation and efficiency?
- How is a diverse set of energy sources beneficial?
- How are renewable and sustainable energy sources the same, and how are they different?

TSA Standards

- Technology Bowl

Task Number 92

Investigate energy demand in a sector.

Definition
Investigation may include

- industrial
- military/government
- community (microgrids).

Process/Skill Questions

- How and where do microgrids operate?
- What makes government facilities different from those of other sectors?
- What is the definition of resiliency, and why is it important?

Task Number 93
Define energy efficiency.

Definition

Definition should include

- reducing energy input to obtain the same output (the importance of getting more output from less input)
- physical limitations of various technologies and energy sources
- the relationship between efficiency and sustainability.

Process/Skill Questions

- How are efficiency and sustainability related? What is an example of a situation where an increase in efficiency does not lead to greater sustainability?
- What are different types of light bulbs? How and why do their efficiencies differ?

ITEEA National Standards

- STEL 3

TSA Standards

- Technology Bowl

Task Number 94

Keep a personal energy log.

Definition

Keeping a log of energy use may include a spreadsheet, a diary, or a portfolio. The log should include

- date(s) and times
- location
- description
- other details of energy use.

Teacher Resources:

- National Energy Education Development (NEED), https://www.need.org/

Process/Skill Questions

- What can be learned by logging energy use?
- Why is it important to be aware of one’s energy use?
- What is the greatest portion of your energy use?

Task Number 95

Identify the components of energy demand.

Definition

Identification should include

- the electric energy grid
- end users
- economic concepts
• innovation
• consumer expectations.

Process/Skill Questions

• What are the elements of the electric energy grid?
• Who are the most common end users of energy?
• What does digitization of the grid mean?

TSA Standards

• Technology Bowl

Preparing for Careers in the Energy Industry

Task Number 96

Examine jobs related to energy.

Definition

Examination should focus on jobs associated with energy sources, energy generation, energy efficiency, energy transmission, and energy distribution, as well as the levels of education and training required for each job. Resources may include Career Clusters, Virginia Labor Market, https://virginiaworks.com/, and the U.S. Bureau of Labor Statistics, https://www.bls.gov/.

Examination may also include job projections and salary information related to energy jobs.

Teacher resource:

• O*NET Online, Employment and Training Administration, U.S. Department of Labor (https://www.onetonline.org/)

Process/Skill Questions

• What are some local job opportunities in energy industries?
• What is the future outlook for careers in energy industries?
• What are the opportunities for advancement in energy careers?
• What are the educational and career pathways for a career in the energy industry?

ITEEA National Standards

• STEL 3

Task Number 97

Participate in a mock interview.

Definition

Participation should include the opportunity to practice interviewing skills prior to an actual interview. Students should play a variety of roles to illustrate interviewee behaviors both desirable (e.g., maintaining eye contact, asking informed questions) and undesirable (e.g., speaking too softly, failing to answer questions completely).

Process/Skill Questions

• How can a job applicant prepare questions to ask during an interview?
- When an interviewee fails to maintain eye contact, what might that indicate to the interviewer?
- What are soft skills needed to be successful in a job?

**TSA Standards**
- Extemporaneous Presentation

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**Task Number 98**

**Prepare a résumé or portfolio.**

**Definition**

Preparation may include a résumé and a combination of electronic and hardcopy documents that are representative of a student's qualifications (i.e., knowledge, skills, abilities).

Preparation should include writing and gathering materials that may include
- an introduction that lists the contents of the portfolio and summarizes the student's experience
- a career-development package that includes a résumé, references, and a sample employment application
- work samples that demonstrate the student's skills
- documentation of the student's practical or work experience
- credentials and student organizations (including OSHA 10)
- community service.

**Process/Skill Questions**
- How often should a résumé or portfolio be updated?
- What materials are suitable for a portfolio?
- What skills and knowledge are industries seeking in new employees?
- Why should key words in a job description appear on a resume?

**ITEEA National Standards**
- STEL 3

**TSA Standards**
- STEM Careers

**SOL Correlations by Task**

<table>
<thead>
<tr>
<th>Develop a timeline of energy innovation throughout history.</th>
<th>English: 11.5, 12.5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Science: ES.6</td>
</tr>
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<td></td>
<td>Social Studies: VUS 8, Govt 9, 12, 15</td>
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<td></td>
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<tr>
<td>Research the processes of regulatory compliance.</td>
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<tr>
<td></td>
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</tr>
<tr>
<td>Define energy.</td>
<td>English: 11.3, 12.3</td>
</tr>
<tr>
<td>Task</td>
<td>Science</td>
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<td>---------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Describe types of energy and their uses.</td>
<td>PH.7, PH.9, PH.11</td>
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<tr>
<td>Describe the flow of energy from source to consumer.</td>
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<tr>
<td>Demonstrate the use of tools and procedures common to jobs in energy industries.</td>
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<tr>
<td>Demonstrate the use of instruments to measure units.</td>
<td>PH.6</td>
</tr>
<tr>
<td>Convert units of measure.</td>
<td>PH.1, PH.11, CH.1</td>
</tr>
<tr>
<td>Analyze renewable and non-renewable sources of energy.</td>
<td>ES.6</td>
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<tr>
<td>Explain energy conversion.</td>
<td>PH.6, ES.6</td>
</tr>
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<td>Explain the purpose of energy regulation.</td>
<td>ES.6</td>
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<td>Identify the agencies involved in energy regulation.</td>
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<tr>
<td>Comply with federal, state, and local safety requirements.</td>
<td>CH.1</td>
</tr>
<tr>
<td>Explain safe working practices around electrical hazards.</td>
<td>CH.1</td>
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<tr>
<td>Inspect course-specific hand and power tools to visually identify defects.</td>
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<tr>
<td>Demonstrate lifting and carrying techniques.</td>
<td>PH.6</td>
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<tr>
<td>Report personal injuries and environmental and equipment safety violations to the appropriate authority.</td>
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<td>Earn the OSHA 10 card.</td>
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<td>Pass a safety exam for lab/site safety and the use of tools and equipment, if applicable.</td>
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<td>11.5, 12.5</td>
</tr>
</tbody>
</table>
Analyze schemes for protection and management of natural gas distribution systems.

Describe the different physical units in which energy sources are measured.

Explain how different energy sources are compared to each other in one common unit.

Compare the percentage of each energy source used in the United States over a period of time.

Explain different end-user sectors and the percentage of energy used by each.

Describe the sectors that comprise energy demand.

Define energy demand.

Investigate energy demand in a sector.

Define energy efficiency.

Keep a personal energy log.

Identify the components of energy demand.

Examine jobs related to energy.

Participate in a mock interview.

Prepare a résumé or portfolio.

### Appendix: Credentials, Course Sequences, and Career Cluster Information

**Industry Credentials (Only apply to 36-week courses)**

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

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

- Construction Technology (8431/36 weeks)
- Renewable Energy (8408/36 weeks)
- Sustainability and Renewable Technologies (8414/36 weeks)
- Energy Demand: Sustainability and Efficiency (ED8411/36 weeks)
- Energy Transmission and Distribution, Advanced (TD8411/36 weeks)
- Power Generation Design and Function (PG8411/36 weeks)
- Engineered Energy Systems (EES8411/36 weeks)

**Career Cluster: Architecture and Construction**
<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations and maintenance</td>
<td>Electrical Power Line Installers and Repairers</td>
</tr>
</tbody>
</table>

**Career Cluster: Science, Technology, Engineering and Mathematics**

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>Civil Engineer</td>
</tr>
<tr>
<td></td>
<td>Civil Engineering Technician</td>
</tr>
<tr>
<td></td>
<td>Electrical Drafter</td>
</tr>
<tr>
<td></td>
<td>Electrical Engineer</td>
</tr>
<tr>
<td></td>
<td>Electrical Engineering Technician</td>
</tr>
<tr>
<td></td>
<td>Electro-Mechanical Technician</td>
</tr>
<tr>
<td></td>
<td>Electronics Engineering Technician</td>
</tr>
<tr>
<td></td>
<td>Industrial Engineer</td>
</tr>
<tr>
<td></td>
<td>Industrial Engineering Technician</td>
</tr>
<tr>
<td></td>
<td>Manufacturing Systems Engineer</td>
</tr>
<tr>
<td></td>
<td>Mechanical Engineer</td>
</tr>
<tr>
<td></td>
<td>Mechanical Engineering Technician</td>
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<tr>
<td></td>
<td>Nuclear Engineer</td>
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<tr>
<td></td>
<td>Petroleum Engineer</td>
</tr>
<tr>
<td></td>
<td>Power Systems Engineer</td>
</tr>
<tr>
<td></td>
<td>Systems Analyst</td>
</tr>
</tbody>
</table>

**Career Cluster: Transportation, Distribution and Logistics**

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health, Safety and Environmental Management</td>
<td>Health, Safety, and Environment Manager</td>
</tr>
<tr>
<td>Logistics Planning and Management Services</td>
<td>Logistics Analyst</td>
</tr>
<tr>
<td>Sales and Service</td>
<td>Customer Service Representative (CSR)</td>
</tr>
<tr>
<td>Transportation Systems/Infrastructure Planning, Management and Regulation</td>
<td>Civil Engineer</td>
</tr>
<tr>
<td></td>
<td>Civil Engineering Technician</td>
</tr>
<tr>
<td></td>
<td>Urban, Regional Planner</td>
</tr>
</tbody>
</table>