Energy Transmission and Distribution, Advanced

TD8411 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
Prerequisites: IT8411

In this advanced course, students use hands-on applications like designing circuits, smart grids, and gas systems to deepen their knowledge of concepts, laws, and theories related to energy transmission and distribution. Students use and interpret engineering and technical drawings.

They explore emerging trends and consider how energy transmission and distribution affect societies and the environment.

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	TD8411	Tasks/Competencies	
Applying Energy Concepts			
39	⊕	Summarize the forms, types, and uses of energy.	
40	⊕	Explain the law of conservation of energy.	
41	⊕	Demonstrate energy transformation for different forms of energy.	
42	⊕	Distinguish between renewable and nonrenewable sources of energy.	
Applying Laws and Theories Related to Energy Transmission and Distribution			
43	⊕	Apply electrical formulas to determine unknown values in circuits.	
44	⊕	Apply geometric, trigonometric, and algebraic formulas for determining lengths.	
45	⊕	Apply gas laws to determine the relationship between pressure, volume, and temperature.	
46	⊕	Model series, parallel, and series-parallel circuits.	
Analyzing Technical and Engineering Drawings			
47	⊕	Explain types of schematics.	
48	⊕	Interpret computer-aided design (CAD) drawings and blueprints.	
49	⊕	Interpret site plans.	
50	⊕	Perform measurements.	

Analyzing the Electrical Grid			
51	⊕	Demonstrate how protective equipment on a circuit increases reliability.	
52	⊕	Analyze demand and load profiles.	
53	⊕	Research grid modernization.	
54	⊕	Design a smart grid.	
55	⊕	Explore energy storage in the grid.	
Analyzing the Gas System			
56	⊕	Demonstrate how system controls increase reliability.	
57	⊕	Analyze supply and demand profiles.	
58	⊕	Research modernization of gas systems.	
Exploring Environmental and Societal Impacts of Energy Transmission and Distribution			
59	⊕	Investigate the environmental impacts of emissions.	
60	⊕	Describe the environmental impacts of constructing energy assets.	
61	⊕	Describe the societal effects of constructing energy assets.	
62	⊕	Investigate trends in component life cycle and waste disposal.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

Applying Energy Concepts

Task Number 39

Summarize the forms, types, and uses of energy.

Definition

Summary should include

- distinguishing between kinetic and potential energy
- explaining different forms of energy
    - thermal (heat)
    - radiant (electromagnetic, including light)
    - chemical (stored in bonds of atoms in molecules)
    - nuclear (stored in the nuclei of atoms)
    - electrical (movement of electrons)
    - motion (mechanical)
    - sound (waves)
    - elastic (coiled spring potential)
    - gravitational (potential energy stored in objects higher than the ground).

Process/Skill Questions

- What is a commercial use of kinetic energy?

ITEEA National Standards

16. Energy and Power Technologies

2. The Core Concepts of Technology

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

TSA Competitive Events

Technology Bowl

Task Number 40

Explain the law of conservation of energy.

Definition

Explanation should include the concept that energy can neither be created nor destroyed; it can only be transformed from one form to another.

Process/Skill Questions

- In what ways can forms of energy be transformed?

ITEEA National Standards

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

TSA Competitive Events

Essays on Technology

Task Number 41

Demonstrate energy transformation for different forms of energy.

Definition

Demonstration should include an example of energy conversion of each form (i.e., thermal, mechanical, chemical, electrical), including labeling

- potential and kinetic energy
- points of energy loss
- points of energy conversion.

Process/Skill Questions

- What is a byproduct of energy loss?
- How does an inverter convert alternating current (AC) to direct current (DC)?
- What are different methods to decrease energy loss?

ITEEA National Standards

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

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

9. Engineering Design

TSA Competitive Events

Principles of Technology (Virginia only)

Task Number 42

Distinguish between renewable and nonrenewable sources of energy.

Definition

Distinction should include

- explaining the difference between renewable and nonrenewable sources
- categorizing sources as renewable or nonrenewable
    - coal
    - water
    - oil
    - nuclear
    - sun
    - wind
    - biomass
    - geothermal.

Process/Skill Questions

- Why is wind a renewable energy source?
- How can tides be used to harness energy?
- What are the differences among renewable, nonrenewable, and inexhaustible energy sources?

ITEEA National Standards

5. The Effects of Technology on the Environment

TSA Competitive Events

Technology Bowl

Applying Laws and Theories Related to Energy Transmission and Distribution

Task Number 43

Apply electrical formulas to determine unknown values in circuits.

Definition

Application should include finding unknown values in series, parallel, and series-parallel circuits using

- Ohm's law
- Watt's law
- Joule's law.

Process/Skill Questions

- What are the differences between Ohm's law and Watt's law?
- What variables are used in Ohm's law? In Watt's law? In Joule's law?
- How does one use Ohm's law to determine watts?

ITEEA National Standards

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

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

Task Number 44

Apply geometric, trigonometric, and algebraic formulas for determining lengths.

Definition

Application should include using the following to determine the lengths of cables, wires, pipelines, etc.:

- Pythagorean theorem
- Root mean square

Process/Skill Questions

- What is the origin of the Pythagorean theorem?
- When would one use the Pythagorean theorem?

ITEEA National Standards

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

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Task Number 45

Apply gas laws to determine the relationship between pressure, volume, and temperature.

Definition

Application should include considering how various gas constituents cause heating values to change when using

- Boyle's law
- ideal gas law
- Charles's law
- Henry's law.

Process/Skill Questions

- When would one use ideal gas law?
- When would one use Boyle's law? Charles's law?

ITEEA National Standards

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

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

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Task Number 46

Model series, parallel, and series-parallel circuits.

Definition

Modeling should include

- drawing the circuit
- building the circuit
- answering word problems by measuring the circuit
- troubleshooting the circuit.

Process/Skill Questions

- What are the advantages of a series circuit?
- What does amperage do in a series-parallel circuit?
- What type of circuit is common in residential wiring, and why?

ITEEA National Standards

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

12. Use and Maintain Technological Products and Systems

TSA Competitive Events

Principles of Technology (Virginia only)

Analyzing Technical and Engineering Drawings

Task Number 47

Explain types of schematics.

Definition

Explanation should include

- pipelines
- transmission
- distribution
- electrical circuits
- controls.

Explanation should also include identifying symbols for components, such as transformers, valves, motors, breakers, pumping stations, etc.

Process/Skill Questions

- What is the purpose of a schematic?
- Why is it important to be able to read a schematic?
- What is the difference between a line diagram and a schematic?

ITEEA National Standards

13. Assess the Impact of Products and Systems

Task Number 48

Interpret computer-aided design (CAD) drawings and blueprints.

Definition

Interpretation should include

- understanding scale
- converting between standard and metric measurements
- identifying standard symbols
- reading mechanical, electrical, and plumbing CAD drawings and blueprints.

Process/Skill Questions

- What are some advantages of using CAD drawings?
- What CAD software is typically used in the energy industry?

ITEEA National Standards

13. Assess the Impact of Products and Systems

TSA Competitive Events

Computer-Aided Design (CAD), Architecture

Computer-Aided Design (CAD), Engineering

Task Number 49

Interpret site plans.

Definition

Interpretation should include

- schedules
- components of drawings
- scale
- topography
- site layout
- security
- geolocation and environmental information.

Process/Skill Questions

- How is the national electric grid subdivided by region?
- Why are site plans not developed to full scale?

- What is the purpose of schedules on a drawing?

ITEEA National Standards

13. Assess the Impact of Products and Systems

TSA Competitive Events

Computer-Aided Design (CAD), Architecture

Task Number 50

Perform measurements.

Definition

Performance should include

- using measurement tools
- measuring site plans
- laying out circuits or pipeline system segments.

Process/Skill Questions

- What is the importance of conducting and/or recording measurements?
- What are three primary measurement tools used in the energy industry, and how are they used?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

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

TSA Competitive Events

Computer-Aided Design (CAD), Architecture

Analyzing the Electrical Grid

Task Number 51

Demonstrate how protective equipment on a circuit increases reliability.

Definition

Demonstration should include

- designing a circuit with protective equipment
- reviewing outage data, including seasonal outages
- projecting circuit outages due to nature or equipment failure
- determining reliability of the circuit.

Process/Skill Questions

- How do local utility companies monitor systems?
- How do local utility companies prevent failure?
- How are seasonal challenges anticipated?

ITEEA National Standards

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

12. Use and Maintain Technological Products and Systems

TSA Competitive Events

Principles of Technology (Virginia only)

Task Number 52

Analyze demand and load profiles.

Definition

Analysis should include

- identifying baseload and demand
- identifying peak load and demand
- calculating load and demand projections.

Process/Skill Questions

- How is baseload determined?
- How does distributed generation affect demand and load profiles?
- How does the grid manage the intermittent nature of wind and solar energy?
- How can energy conservation help with peak demand issues?

ITEEA National Standards

13. Assess the Impact of Products and Systems

Task Number 53

Research grid modernization.

Definition

Research may include the technologies used and challenges associated with

- distributed energy systems
    - off-grid
    - on-grid
- demand response
- net metering
- resiliency
- voltage and voltage regulation
- storage.

Process/Skill Questions

- What are the advantages and disadvantages of using an off-grid vs. an on-grid system?
- What is Virginia's net metering law? How does it compare to those of other states?

- What role does storage play in grid modernization?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

Task Number 54

Design a smart grid.

Definition

Design should include

- generation baseload
- distributed energy systems for transmission and distribution
- storage
- smart meters
- controls
- intelligent line devices
- demand/load.

Process/Skill Questions

- How have smart grids improved efficiency in transmission and distribution?
- What incentives have expanded smart grid implementation?
- What regulations limit smart grid design?

ITEEA National Standards

9. Engineering Design

TSA Competitive Events

Principles of Technology (Virginia only)

Task Number 55

Explore energy storage in the grid.

Definition

Exploration should include

- difficulties in storing electricity
- pumped storage (e.g., Bath County Pumped Storage)
- other gravitational storage
- air storage
- battery storage.

Process/Skill Questions

- How are battery storage and smart grids used in electric vehicles?
- What is the significance of the Bath County Pumped Storage facility?
- Why is it so difficult to store electricity?
- What are the battery types and materials? Which ones are used for homes and automobiles?

ITEEA National Standards

13. Assess the Impact of Products and Systems

Analyzing the Gas System

Task Number 56

Demonstrate how system controls increase reliability.

Definition

Demonstration should include

- designing a system with controls
- reviewing outage data, including seasonal outages
- projecting system outages due to natural forces, external forces, or equipment failure

- determining the reliability of the system.

Process/Skill Questions

- What are the advantages of using remote-controlled gas valves?
- What is *looping*?
- What seasonal challenges affect the gas system?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

9. Engineering Design

Task Number 57

Analyze supply and demand profiles.

Definition

Analysis should include

- identifying pressure needs to meet demand
- identifying market constraints specific to the system
- calculating end-user total connected load
- calculating pressure drop over a specified distance in the system
- explaining storage mechanisms for meeting peak demand
- understanding the use of telemetry and supervisory control and data acquisition (SCADA) in monitoring and controlling the gas system.

Process/Skill Questions

- When is it necessary to heat the gas?
- What is *telemetry*?
- What percentage of natural gas supply is used for electricity production? What are the seasonal differences?
- What are the advantages and disadvantages of using natural gas vs. other energy sources for electricity production?

ITEEA National Standards

13. Assess the Impact of Products and Systems

Task Number 58

Research modernization of gas systems.

Definition

Research should include

- changes in pipeline materials, inspections, and monitoring
- modernization efforts driven by major incidents in the natural gas industry
- the risks that have been reduced in the industry through modernization
- methods for inspecting pipelines internally and externally
- the emerging role of unmanned aerial vehicles (UAVs) in monitoring and inspecting system components.

Process/Skill Questions

- How has the introduction of shale gas influenced modernization in the gas industry?
- What major incidents have driven changes in safety regulations in the gas industry?
- What are emerging sources of natural gas?
- What is *cathodic protection*?
- What is *hydraulic fracturing*?

ITEEA National Standards

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

7. The Influence of Technology on History

Exploring Environmental and Societal Impacts of Energy Transmission and Distribution

Task Number 59

Investigate the environmental impacts of emissions.

Definition

Investigation should include

- the concept of carbon footprint
- sources of carbon emissions (e.g., methane, carbon dioxide)
    - natural
    - man-made
- effects of carbon emissions
- the amount of carbon emission per energy source
- other emissions from energy production (e.g., SO2, NOx, mercury, warm water)
- the use of environmental controls to reduce emissions
- carbon tax and other related legislation.

Process/Skill Questions

- Why are carbon emissions an environmental concern?
- Which is a more potent greenhouse gas, carbon dioxide or methane?
- What is the SAVE Act? How does it affect greenhouse gas emissions in Virginia?

ITEEA National Standards

5. The Effects of Technology on the Environment

TSA Competitive Events

Essays on Technology

Task Number 60

Describe the environmental impacts of constructing energy assets.

Definition

Description may include

- examples of energy assets (e.g., gas pipelines, generation facilities, transmission and distribution lines, coal mines, gas regulation stations, gas compressor stations, electrical substations)
- land use (e.g., powerlines, pipelines, photovoltaic farms)
- reclamation
- decommissioning
- the role of permits
- effects of construction on animal habitats, biodiversity
- dams, sedimentation, water warming, and fish migration
- regulations and policies that govern construction of energy assets.

Process/Skill Questions

- What factors influence the location of energy production facilities?
- How are transmission and distribution component site locations chosen?
- Why is there opposition to solar farms?
- What are the challenges involved in decommissioning?
- How might transmission lines potentially affect habitats?

ITEEA National Standards

16. Energy and Power Technologies

5. The Effects of Technology on the Environment

9. Engineering Design

Task Number 61

Describe the societal effects of constructing energy assets.

Definition

Description may include

- the concept of social justice
- public safety risk
- property value
- public health
- access to education and training
- job opportunities
- tax revenue
- infrastructure

- eminent domain
- sound
- regulations and policies that govern construction of energy assets.

Process/Skill Questions

- How are property values influenced by energy asset construction in the area?
- What potential public health concerns are associated with the construction of power plants?
- What are some job opportunities created by the energy industry?
- Where can individuals find training for emerging energy production careers?
- How can the construction of energy assets drive local revenue?

ITEEA National Standards

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

TSA Competitive Events

Essays on Technology

Task Number 62

Investigate trends in component life cycle and waste disposal.

Definition

Investigation may include

- battery recycling
- solar panel recycling and disposal
- coal ash storage
- spent fuel disposal
- wind turbine blades
- mine and power plant decommissioning
- reclamation
- gas stream contaminants
- legacy materials (e.g., asbestos, mercury).

Process/Skill Questions

- How has waste been managed historically?
- What government agencies oversee waste disposal?
- What are the trends in materials recovery that affect component life cycles?

ITEEA National Standards

16. Energy and Power Technologies

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

TSA Competitive Events

Technology Bowl

SOL Correlation by Task

39	Summarize the forms, types, and uses of energy.	English: 10.5, 11.5 Science: PH.6, PH.7
40	Explain the law of conservation of energy.	English: 10.5, 11.5 Mathematics: A.4, AII.3, MA.3 Science: PH.6
41	Demonstrate energy transformation for different forms of energy.	Science: PH.6
42	Distinguish between renewable and nonrenewable sources of energy.	English: 10.5, 11.5 History and Social Science: GOVT.12, VUS.14, WG.17, WHII.14 Science: ES.6
43	Apply electrical formulas to determine unknown values in circuits.	English: 10.5, 11.5 History and Social Science: WHII.8 Mathematics: A.4, AII.3 Science: PH.11
44	Apply geometric, trigonometric, and algebraic formulas for determining lengths.	History and Social Science: WHI.5 Mathematics: A.4, G.3, G.8, T.8, AII.3

45	Apply gas laws to determine the relationship between pressure, volume, and temperature.	English: 10.5, 11.5 Mathematics: A.4, A.8, AII.3, AII.10 Science: CH.5
46	Model series, parallel, and series-parallel circuits.	English: 10.5, 11.5 Science: PH.11
47	Explain types of schematics.	English: 10.5, 11.5 Science: PH.11
48	Interpret computer-aided design (CAD) drawings and blueprints.	English: 10.5, 11.5 Mathematics: A.1, A.4
49	Interpret site plans.	English: 10.5, 11.5
50	Perform measurements.	
51	Demonstrate how protective equipment on a circuit increases reliability.	English: 10.5, 11.5
52	Analyze demand and load profiles.	English: 10.5, 11.5 Mathematics: A.4, AFDA.1, AFDA.3, AFDA.4, AII.3, AII.6, AII.7, AII.9, COM.7, PS.4*
53	Research grid modernization.	English: 10.5, 10.8, 11.5, 11.8
54	Design a smart grid.	
55	Explore energy storage in the grid.	English: 10.5, 11.5
56	Demonstrate how system controls increase reliability.	English: 10.5, 11.5
57	Analyze supply and demand profiles.	English: 10.5, 11.5
58	Research modernization of gas systems.	English: 10.5, 10.8, 11.5, 11.8 History and Social Science: VUS.14, WHII.14
59	Investigate the environmental impacts of emissions.	English: 10.5, 11.5 History and Social Science: VUS.14, WHII.14
60	Describe the environmental impacts of constructing energy assets.	English: 10.5, 11.5 History and Social Science: VUS.14, WHII.14
61	Describe the societal effects of constructing energy assets.	English: 10.5, 11.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.15, GOVT.16

62	Investigate trends in component life cycle and waste disposal.	English: 10.5, 11.5 History and Social Science: GOVT.12, VUS.14, WG.17, WHII.14

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- Building Science Principles Examination
- 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.*

- Introduction to Energy Transmission and Distribution (IT8411/36 weeks)

Career Cluster: Energy	
Pathway	**Occupations**
Energy Efficiency	**Electrical Engineer** **Electrician** **Environmental Engineer** **Environmental Engineering Technician** **Environmental Science and Protection Technician** **Environmental Scientist** **HVAC and Refrigeration Mechanic or Installer**
Fuels Production	**Chemical Engineer** **Chemist** **Continuous Mining Machine Operator** **First-Line Supervisor of Transportation and Material-Moving Machine and Vehicle Operator** **Geological Technician** **Petroleum Engineer** **Petroleum Technician** **Service Unit Operator, Oil, Gas, and Mining** **Wellhead Pumper**
Power Generation	**Control and Valve Installer, Repairer** **Electrical Engineering Technician** **Electronics Engineer**

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

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

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
	Transportation Manager
Science and Mathematics	**Chemist** **Ecologist** **Environmental Scientist** **Geodetic Surveyor** **Geoscientist** **Research Chemist**

Career Cluster: Transportation, Distribution and Logistics	
Pathway	**Occupations**
Health, Safety and Environmental Management	**Health, Safety, and Environment Manager**
Logistics Planning and Management Services	**Logistics Engineer**